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PALAEOPATHOLOGY OF CRANIAL REMAINS FROM PREDYNASTIC NAQADA, EGYPT

BY

MARNIE KAREN BARTELL ©

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of MASTER OF ARTS.

DEPARTMENT OF ANTHROPOLOGY

EDMONTON, ALBERTA

FALL, 1994

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UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled PALAEOPATHOLOGY OF CRANIAL REMAINS FROM PREDYNASTIC NAQADA, EGYPT submitted by MARNIE KAREN BARTELL in partial fulfillment of the requirements for the degree of MASTER OF ARTS.

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June 30, 1994

DEDICATION

In loving memory of my grandfather
The Rev. Dr. Frederick W. Lenz

ABSTRACT

This study examines the palaeopathological lesions observed in the cranial remains from Predynastic Naqada, Egypt. The sample consists of 132 skulls from Cemetery T (n=36), Cemetery B (n=34), and the Great Cemetery (n=62). Naqada, the largest and one of the most important Predynastic Egyptian sites, was excavated from 1894-1895 by Sir William Matthew Flinders Petrie. Previous interpretations of the artifactual remains indicate clear evidence of social stratification at Naqada. The individuals buried in Cemetery T are said to be of a higher status than are the individuals buried in Cemetery B and the Great Cemetery. A palaeopathological analysis of the cranial remains from these cemeteries was conducted to determine if social status affected the health of the ancient Egyptians at Naqada. The skulls were examined for macroscopic evidence of pathological lesions. Disease frequencies were subsequently calculated and compared between the high status and low status cemeteries. Biparietal thinning, localized infection, and arthritis of the atlanto-occipital joint were observed in low frequencies. Temporomandibular joint arthritis and anemia were more prevalent. Disease frequencies were relatively similar between the cemeteries, with one exception. Low status middle adult females revealed significantly higher frequencies of porotic hyperostosis of the vault than did high status middle adult females. This suggests that although social stratification affected the Naqada mortuary remains, the impact of social position on the lifestyles and health of the ancient inhabitants of Naqada was restricted to middle adult females, who experienced additional stresses associated with multiple pregnancies and lactation.

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Chapter 1:
INTRODUCTION

Although studies tend to overlook the Egyptian Predynastic period in favor of the more visibly spectacular and accessible Dynastic era (Arkell, 1975; Butzer, 1976; Kemp, 1977; Rice, 1990; Trigger, 1983), a complete understanding of ancient Egyptian civilization requires knowledge of both phases. Dynastic Egypt (circa 3000 B.C. to 30 B.C.) often attracts attention with its elaborate hieroglyphics, abundant art, and monumental architecture, but the earlier developmental stage of the civilization is equally impressive (Rice, 1990; Smith, 1983; Trigger, 1983; Wenke, 1990). In only one thousand years, Predynastic Egypt (circa 4000 B.C. to 3000 B.C.) was transformed from a series of independent farming villages into a unified and highly structured state (Bard, 1989: 225; 1992). It also developed in the absence of factors common to the formation of other ancient states, including basic resource competition, interregional trade, external military threats, and urbanization (Bard, 1992; Kemp, 1991). Ancient Egypt instead arose out of the unique Nile-dominated geography which supported the adoption of agriculture (circa 5500 B.C.) and village settlement at a time when the climate was becoming more arid (Bard, 1987, 1989; Hamroush, 1986; Hassan, 1988; Hoffman, 1979; Kemp, 1991; Rice, 1990; Wenke, 1989, 1990). The Predynastic period is particularly notable because it contains the roots of the ideology which allowed for the subsequent development of the ancient Egyptian state (Bard, 1989; Hoffman, 1979; Kemp, 1991).

Unfortunately, due to a lack of evidence, the origins of ancient Egypt are not yet fully understood (Bard, 1989; Hassan, 1988; Trigger, 1983). Information is mainly restricted to archaeological data, because the Predynastic period predates the development of writing (Arkell, 1975; Bard, 1989, 1992; Hoffman, 1979). In addition, the archaeological evidence is itself limited, because Predynastic settlement sites throughout Egypt have largely been destroyed or buried by the annual Nile floods and by thousands of years of subsequent settlement and cultivation (Arkell, 1975; Bard, 1992; Wenke, 1989). Evidence is also limited because the Predynastic cemeteries which managed to survive, because of their location beyond the floodplain (Kemp, 1973; Hassan, 1988), were excavated mainly at the turn of this century before strict excavation and recording methods were established (Bard, 1992; Hoffman, 1979). As a result, the burial information is often far from complete (Arkell and Ucko, 1965; Bard, 1987; Hays, 1983; Hoffman, 1979; Wenke, 1989). Nonetheless, Upper Egyptian mortuary remains do provide much of what is known about the

Predynastic period (Bard, 1987, 1989, 1992; Baumgartel, 1960; Guksch, 1991).

The limited Predynastic evidence makes detailed interpretations about the origins of ancient Egypt difficult. Alternative sources are therefore required for studying the effects that the rapidly developing civilization had upon its early inhabitants. One useful source of information is the study of skeletal remains. Pathological lesions indicative of illness and injury are often observable in human bones, and evidence of disease can be used to help reconstruct the lifestyles of past Egyptians. Strouhal (1981: 241) suggests that "human remains are of at least the same value as cultural ones".

The analysis of skeletal remains is particularly useful given the mortuary context of the Predynastic period. The hot and arid climate of Egypt, which has changed little since antiquity, allows for the excellent preservation of bones (Armelagos et al., 1980; Butzer, 1976; Hassan, 1988; Wenke, 1990). Natural mummification, for example, was not uncommon in Egypt (Bard, 1992; Hoffman, 1979). Furthermore, the ancient Egyptians were concerned with preserving the deceased, since their culture was based on a strong belief in the afterlife (Bard, 1992; Hoffman, 1979; Rice, 1990; Spencer, 1982). The later development of artificial mummification methods, during Dynastic times, offers additional evidence for this belief (Bard, 1992). The study of diseases in antiquity also has a long history in ancient Egypt and Nubia. Sir Marc Armand Ruffer, Sir Grafton Elliot Smith, and Frederick Wood Jones helped lay the foundations for the subdiscipline of palaeopathology (Manchester, 1987; Ortner, 1991; Ortner and Putschar, 1985; Rothschild and Martin, 1993) with their studies of Egyptian mummies and Nubian skeletal remains (Jones, 1908; Ruffer, 1910, 1911a, 1911b, 1913, 1918, 1921; Ruffer and Rietti, 1912; Ruffer and Willmore, 1914; Smith, 1907, 1912; Smith and Jones, 1910). Ruffer, for example, has been accredited with suggesting that the term 'palaeopathology' be used for the study of past illnesses and injuries (Steinbock, 1976). These original studies stimulated further interest in the diseases of the ancient Egyptians. Such analyses may be classified into three general areas of study. First, many examinations have considered the soft tissues and radiographs of Dynastic mummies (e.g., Benassi and Ragni, 1973; Benitez and Lynn, 1980; Bourriau and Bashford, 1980; Christensen, 1969; Cockburn et al., 1975; Cockburn et al., 1983; Delorenzi and Mancini, 1973; El-Rakhawy et al., 1971; Gray, 1967, 1973; Masso, 1977; Moodie, 1931; Pahl, 1980, 1986; Peck, 1980; Rowling 1961, 1967a, 1967b, 1967c, 1967d; Sandison, 1962, 1967a, 1967b, 1967c, 1972, 1980; Sandison and Wells, 1967a, 1967b; Waldron, 1991; Walker et al., 1987). Second, the skeletons of ancient Nubia received considerable attention following the international UNESCO salvage campaigns of the

1960s and 1970s associated with the construction of the Aswan High Dam (e.g., Armelagos, 1968, 1969; Armelagos and Chrisman, 1988; Armelagos et al., 1984; Arriaza et al., 1993; Burrell et al., 1986; Carlson, 1976; Carlson et al., 1974; Hinton and Carlson, 1979; Kilgore, 1989; Martin et al., 1981; Prendergast Moore et al., 1986; Race et al., 1967; Race et al., 1968; Race et al., 1972; Sandford et al., 1983; Sheridan et al., 1991; Van Gerven et al., 1981). Finally, studies of Egyptian skeletons have also been conducted (e.g., Bourke, 1967, 1972; Cave, 1939; Courville, 1949; Derry, 1940; Given, 1928; Hussein, 1951; Marro, 1951; Møller-Christensen, 1967; Morse, 1967; Morse et al., 1964; Peluso, 1980; Podzorski, 1990; Salama and Hilmy, 1950; Salib, 1962, 1967; Satinoff, 1968, 1972; Shaaban, 1984; Strouhal and Vyhmanek, 1982; Watermann, 1960; Wells, 1963), but the majority have been limited to Dynastic remains with only occasional references to Predynastic materials.

The Upper Egyptian site of Naqada is a logical setting in which to study the diseases of the early Egyptians, because it is the largest Predynastic site ever discovered. In 1894 and 1895, Sir William Matthew Flinders Petrie excavated nearly 2200 graves from three cemeteries at Naqada, which he named the Great New Race Cemetery, Cemetery B, and Cemetery T. Although many early archaeologists disposed of the skeletal remains they uncovered (Manchester, 1987; Strouhal, 1981), Petrie fortunately recognized the value of skeletons at Naqada and retained them, thereby providing a unique osteological sample for future analyses. Naqada is also one of the most important sites in our understanding of Predynastic Upper Egypt since it was likely a political centre and one of the earliest sites to reveal evidence of social stratification. Individuals buried in the Naqada cemeteries were accompanied by numerous grave offerings, such as flint knives, copper awls, slate grinding palettes, carved stone figurines, amulets, beads, and pottery (Petrie and Quibell, 1896). The grave goods reflected aspects of everyday life, as well as, an individual's relative social position (Hoffman, 1979). Based on the quality and quantity of the grave goods, the size and construction of the graves, and the exclusiveness of the cemeteries, it is apparent that the high status individuals were buried in Cemetery T, while the low status individuals were interred in Cemetery B and the Great Cemetery. Although Cemetery T is very small, with only 58 graves, it revealed the largest tombs and the largest numbers of grave goods. Petrie attributed these burials to the wealthy inhabitants of Naqada (Petrie and Quibell, 1896). Some researchers believe that the Cemetery T graves were reserved for a ruling elite, foreshadowing the tombs of the Dynastic Pharaohs (Bard, 1989, 1992; Case and Payne, 1962; Kemp, 1973, 1991). Others believe the graves were reserved for a special-status class (Davis, 1983). Although various interpretations of the Naqada artifacts exist, none are directly in conflict. What is important is that clear grave differences exist between the cemeteries. For the purposes of this study the individuals buried in Cemetery T will be referred to as 'high status', while the individuals buried in the Great Cemetery and Cemetery B will be referred to as 'low status'.

The possible effects that social stratification had upon the health and lifestyles of the Predynastic Egyptians may be tested through palaeopathological analyses of the skeletal remains from Naqada. Because social status can affect an individual's exposure to pathogens, injuries, and food resources, socioeconomic differences may be reflected in pathological patterns preserved in human bony remains. Modern analogies suggest that low status individuals are more likely to suffer from conditions associated with inadequate sanitation, poor hygiene, heavy work loads, and malnutrition than are higher status individuals. However, social stratification was much less pronounced in the Predynastic period than in the Dynastic era. To date, predynastic evidence of social stratification during the Predynastic is limited to grave offerings and grave sizes, whereas Dynastic displays of wealth are much more pronounced in the form of monumental architecture, such as the Fourth Dynasty pyramids of Giza. It is possible that the early stages of social stratification may have been only symbolic and had yet to affect aspects of everyday life and health in ancient Egypt.

Given that a better understanding of ancient Egyptian civilization is made possible by studying the Naqada skeletal remains, the primary purpose of this thesis is to address the question: did the emergence of social stratification affect the health of the ancient Predynastic Egyptians from Naqada? The specific research objectives are: (1) to identify pathological lesions and to diagnose diseases preserved in the skulls from Naqada; (2) to calculate demographic patterns of disease frequencies within each cemetery; (3) to compare and contrast the prevalence of disease between the cemeteries; and (4) to demonstrate whether or not these intra- and inter-cemetery pathological patterns relate to the previously identified social status differences.

This thesis centers around the possible relationship between disease and social status. In order to provide a context for this relationship, chapter two describes the cultural history of the Upper Egyptian Predynastic period and the site of Naqada. Chapter three outlines the skeletal materials used in this study and describes the methods of identifying pathological lesions, differentially diagnosing diseases, and statistically comparing disease frequencies. Chapter four provides a broad review of the conditions observed in the Naqada skulls. Chapters five and six follow with a discussion of the most commonly observed pathological lesions: temporomandibular joint arthritis and porotic hyperostosis, respectively. Finally, chapter seven provides summaries and conclusions.

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Chapter 2:
THE CULTURAL AND ARCHAEOLOGICAL CONTEXT OF THE PREDYNASTIC UPPER EGYPTIAN SITE OF NAQADA

INTRODUCTION

This study evaluates osteological evidence of disease in the context of available archaeological information in order to interpret more comprehensively the sociocultural nature of the Predynastic Upper Egyptian site of Naqada. This chapter outlines the temporal and spatial settings in which this analysis is based.

THE EGYPTIAN PREDYNASTIC PERIOD

The Egyptian Predynastic period is characterized by a relatively rapid development of a hierarchical state from small farming villages. This period began at approximately 4000 B.C. and ended with the unification of Upper and Lower Egypt around 3000 B.C., thereby signalling the beginning of the Dynastic phase of Egyptian history. This highly developed state did not appear instantly, however, but instead underwent a continuous development from Predynastic times (Baines and Malek, 1980; Bard, 1987; Guksch, 1991; Hassan, 1988; Rice, 1990; Trigger, 1983). The development of the Egyptian civilization was largely made possible by its unique Nile geography rather than by more obvious factors such as urbanization, resource competition, and external pressure (Hassan, 1988).

The Nile river cut a wide ravine in the desert plateau. Each year the heavy rains in the Ethiopian highlands washed down into the Nile, which subsequently flooded its banks depositing rich silts. This resulted in narrow stretches of fertile land on either side of the river that allowed for the practice of agriculture in this otherwise inhospitable region (Kemp, 1991). It is generally agreed, however, that the development of agriculture in Egypt occurred later than in neighboring civilizations such as Mesopotamia (Hoffman, 1979; Trigger, 1983). The diverse Mesopotamian environment supported a larger population base that allowed for an earlier adoption of agriculture (Trigger, 1983). Unlike other ancient states, the civilization of ancient Egypt was able to develop without cities. The geographical limits set by the Nile inhibited large population growth in Egypt (Hassan, 1988; Wenke, 1989), until more recently when large-scale irrigation was developed and the Aswan High Dam was constructed (Hassan, 1988). Basic resource competition and trade were not necessary in Predynastic Egypt because of the relatively rich and homogenous Nile environment (Bard, 1989; Wenke, 1989, 1990). The Nile geography also isolated ancient Egypt in the early periods from external military pressures, thereby allowing it to develop independently. It is argued that the early Egyptian state arose out of attempts to control the insecurity created by fluctuations in crop yields (Bard, 1992; Hassan, 1988; Kemp, 1991; Rice, 1990). For example, the leaders would have controlled access to surplus stores of grain. They legitimized their power and the stratification of society with displays of wealth in the form of grave goods (Bard, 1989; Hassan, 1988). The resulting funerary industry stimulated the Egyptian economy and promoted trade within and outside of Egypt (Kemp, 1991; Trigger, 1983). The emergence of social stratification and the competition for grave goods likely contributed to the spread of ideas and artifacts, as interactions intensified. Trade was made easier in later Predynastic times by advancements in river and land transport, which are suggested by the appearance of boats and the domestication of the donkey (Hassan, 1988).

Lifestyles of the Predynastic Egyptians were affected by the rapidly developing civilization. The majority of evidence comes from a core area in Upper Egypt, which includes the sites of Matmar, Mostagedda, Badari, Ballas, Naqada, Armant, Diospolis Parva (Hu), and Hierakonpolis (Figure 2-1) (Bard 1992; Baumgartel, 1955; Kemp, 1973; Wenke, 1989). It is generally agreed that the roots of the Egyptian ideology and culture developed in this region. Four cultural phases of the Upper Egyptian Predynastic period have been identified from pottery styles. These include the following stages: Badarian (ca. 4000-3900 BC), Amratian or Naqada I (ca. 3900-3650 BC), Gerzean or Naqada II (ca. 3650-3300 BC), and Semainean or Naqada III (ca. 3300-3050 BC) (Arkell, 1975; Hassan, 1988: 138). This chronological scheme is based on Petrie's original sequence dates that were in turn derived from the pottery styles of Naqada and Diospolis Parva (Arkell, 1975; Hassan, 1988; Petrie, 1920, 1974). As the names suggest, the site of Naqada spanned the Amratian (Naqada I) to Semainean periods (Naqada III).

Prior to the Predynastic period, the ancient Upper Egyptians had a mixed economy of fishing, hunting, and plant gathering. From the Naqada I to the Naqada III time periods they continued to hunt and fish, but increasingly relied on the cultivation of barley and wheat and the raising of sheep/goats and cattle (Hassan, 1988; Trigger, 1983).

Amratian dwellings likely consisted of wind-breaks and oval clay huts, although the evidence is minimal. Typical huts had wooden post frames and hearths, but no doors, and were located next to animal enclosures, storage pits, and refuse areas. Hassan (1988) suggests that the Amratian settlements were small and dispersed.

Upper Egyptians were buried in cemeteries located on the edge of the desert. Naqada I burials were comprised mainly of oval graves. Individuals were placed in contracted positions on their left sides with their heads to the south and facing west. Some Predynastic graves revealed missing or extra skulls. Hassan (1988: 31) suggests that this was due to dismemberment practices and not because of head-hunting or cannibalism. The Amratian period revealed little evidence of social differentiation, although grave goods were placed alongside the skeletons and included pottery, lithics, human figurines, disc maceheads, and combs and slate palettes in forms of animals. The pottery consisted mainly of polished red wares and white cross-lined painted wares. Most of the stone tools were bifaces and included distinctive fish-tail and large rhomboid knives. Copper was still relatively rare in Amratian times (Trigger, 1983).

Dwellings appear to have changed dramatically from the Naqada I to the Naqada II phase. Amratian oval huts were likely replaced by Gerzean rectangular brick houses resembling later Dynastic dwellings (Hassan, 1988; Trigger, 1983). The brick structures consisted of rectangular pits with mud plastered walls and roofs supported by poles. They also commonly contained ovens and storage pots (Arkell, 1975; Hassan, 1988; Trigger, 1983). Large houses, which were possibly residences of the elite, were discovered at South Town in the site of Naqada. From the limited evidence available, it appears that the settlements of Predynastic Egypt became larger and wealthier over time. Unlike the Amratian sites, the Gerzean sites were dispersed from Nubia to Lower Egypt.

Social stratification appears to have developed during Gerzean times. Graves became more sophisticated and grave goods more varied (Trigger, 1983). Niches for grave goods or human remains were sometimes added to the graves. In addition, brick burial chambers were discovered in Cemetery T at Naqada (Baumgartel, 1970) and in Tomb 100 at Hierakonpolis (Kemp, 1973). Copper implements became more common and ranged in form from knives and axes to needles and fish-hooks (Trigger, 1983). Stone tools and decorative designs were apparently of better quality. Scimitar-like knives and intricate decorations, for example, were observed in Gerzean times (Trigger, 1983). Unlike the preceding Amratian period, Gerzean times were characterized by the first appearance of foreign influences. As a result, stylistic changes were common. Pottery, for example, consisted of local rough ware types, as well as fancy and wavy-handled wares derived from Southwest Asian styles. Pottery was no longer manufactured exclusively from Nile clay, but also from a limestone and clay mixture obtained from Qena and Badari. Beads and amulets appeared, which were made of gold and foreign materials, such as lapis lazuli from Afghanistan (Trigger, 1983). Whether these influences result from cultural diffusion, trade, or population movements is a matter of some debate. Brace et al. (1993), for example, suggest that Predynastic Naqada shows biological affinities to South Asia, Somalia, and Nubia, while Prowse (1994) has demonstrated a connection to Lower Nubia.

The Naqada III or Semainean period spanned a relatively short period of time just prior to the unification of Upper and Lower Egypt. It was known for late ware pottery that probably developed at Naqada and Diospolis Parva (Arkell, 1975).

Compared to the knowledge of the Upper Egyptian Predynastic, knowledge of the Lower Egyptian Predynastic is very limited. However, information from several Lower Egyptian sites, including the Fayum, Merimda, El-Omari, and Maadi, suggest that the cultural styles of Lower Egypt were initially distinct from those of Upper Egypt (Arkell, 1975; Hassan, 1988; Trigger, 1983). The Lower Egyptians were mainly buried in settlements instead of cemeteries, and their communities were much larger than the Upper Egyptian villages. In addition, Lower Egyptian pottery and vessels were mainly undecorated, unlike Upper Egyptian wares (Trigger, 1983: 26).

The bases of ancient Egyptian culture were rooted in the Predynastic period. Although Predynastic evidence is mainly restricted to cemetery remains, mortuary information can be used to interpret the broader cultural context, since it is usually assumed that "cemetery organization = social organization" (Hodder, 1979: 163; also Bard, 1992; Chapman, 1987; Tainter, 1983). A burial usually represents the cultural beliefs about death, as well as the relationship of the deceased to the community (Alekshin, 1983; Bard, 1992; Tainter, 1983). Social stratification, for example, can often be identified in ancient graves. The quantity and quality of grave goods is often thought to be related to the social status of the associated individual (Cannon, 1989; Tainter, 1983), as is the amount of energy expended in burying the person (Alekshin, 1983). While the quantity of grave goods is easily identified, relative quality is sometimes difficult to assess (Davis, 1983). In addition, ethnographic examples exist in which stratified societies have indistinguishable graves (Cannon, 1989; Chapman and Randsborg, 1981). For example, from Victorian to modern English times grave designs became less elaborate and more similar among the classes, thereby masking the underlying social stratification (reviewed in Cannon, 1989). These problems are minimal, however, in the context of ancient Egypt. By the First Dynasty there is clear evidence of a stratified society. The lives of the ancient Egyptians were dedicated to the Cult of the Dead and they had immense respect for the political authority of their rulers. During Dynastic times, for example, they kept elaborate lists of the Pharaohs, such as the Palermo Stone (Kemp, 1991), and constructed large monuments symbolizing the authority of the kings (Bard, 1992). It is possible that the quality of grave goods can also be measured by the rarity of their materials.

THE SITE OF NAQADA

The mortuary evidence of the Predynastic period can be readily interpreted given the culture of the ancient Egyptians and the adequate preservation of material and skeletal remains, such as at the site of Naqada. The Upper Egyptian Predynastic site of Naqada was excavated in 1894-1895 under the direction of Sir William Matthew Flinders Petrie. Within a period of roughly five months, Petrie unearthed nearly 2200 graves. He was assisted by Quibell and several students, including Price, Grenfell, and Duncan, and a crew of local workers (Petrie and Quibell, 1896).

Not only was Naqada the first Predynastic site ever discovered, it is also the largest found so far, and remains one of the most important sites for our understanding of early ancient Egypt (Aldred, 1987; Arkell, 1975; Arkell and Ucko, 1965; Bard, 1987, 1989, 1992; Baumgartel, 1955, 1970; Castillos, 1981, 1982; Davis, 1983; Fagan, 1975; Hassan, 1988; Hoffman, 1979; Petrie, 1931). The cultural chronology of the Upper Egyptian Predynastic period, for example, is largely based on the Naqada findings. Petrie developed the sequence dating method by applying seriation techniques to the pottery styles observed at Naqada and Diospolis Parva (Baumgartel, 1970; Hoffman, 1979; Petrie, 1901, 1920; Wenke, 1990). He ranked the pottery from 900 graves into a relative order. He then divided the pottery into 51 equal groups and assigned each group a consecutive number or sequence date from 30 to 80 (Petrie, 1920). Naqada also seems to provide evidence of the origins of social stratification in Upper Egypt that foreshadows the later development of rule by divine kingship (Bard, 1992; Hoffman, 1979).

Naqada is located on the west bank of the Nile approximately 25 kilometres northwest of Luxor (Figure 2-1). In Predynastic times, it consisted of two towns: South Town and North Town; and three cemeteries: the Great New Race Cemetery, Cemetery B, and Cemetery T (Figures 2-2 and 2-3) (Petrie and Quibell, 1896).

South Town, which was also known as Nubet or the 'town of gold', was larger and better preserved than North Town (Baines and Malek, 1980; Baumgartel, 1970; Kemp, 1991; Rice, 1990). South Town originated in the Naqada I time period and was partially built over during the course of the New Kingdom (Baumgartel, 1955, 1970). It may have been a Predynastic capital because its associated cemeteries revealed early evidence for social stratification (Baumgartel, 1955), and it was affiliated with the cult of the god Seth in later Dynastic times (Kemp, 1991; Rice, 1990). In addition, Naqada was strategically located across the Nile from the Wadi Hammamat, which led to a gold mining region and to the Red Sea trade of precious stones (Trigger, 1983). Turquoise, for example, was not local to ancient Egypt but was found in Naqada cemeteries in the form of grave goods (Bard, 1987; Baumgartel, 1970). The three Naqada cemeteries were roughly contemporaneous, although the Great and B cemeteries appeared slightly earlier (Baumgartel, 1970; Davis, 1983; Bard, 1989). Cemetery B and the Great Cemetery likely came into existence during the late Naqada I or the Naqada I-II transition (Hassan, 1988), whereas Cemetery T did not appear until Naqada II times (Davis, 1983). Although radiocarbon dates have been obtained for these cemeteries, they are not universally accepted due to callibration inconsistencies and possible contamination of some samples (Hassan, 1984, 1988).

The largest cemetery at Naqada was located just to the west of South Town. Petrie named this burial ground the Great New Race Cemetery, because he believed that Naqada had been inhabited by foreign invaders (Petrie, 1901, 1920; Petrie and Quibell, 1896). He failed to recognize the early Egyptian age of Naqada, because it was the first Predynastic site ever discovered, and the pottery styles and burial practices were unlike anything seen previously in Egypt. The Predynastic date of Egypt was instead solidified by Jacques de Morgan's subsequent discovery of the tomb of Queen Neithotep at Naqada (Baumgartel, 1955, 1970; Hoffman, 1979; Spencer, 1982).

Cemetery B was named after Kom Belal, a nearby mound, and was located one kilometre south of the Great Cemetery (Bard, 1989). Cemetery T was named for the two tumuli next to it and was situated between the Great and B Cemeteries (Petrie and Quibell, 1896). Table 2-1 presents the number of graves that Petrie excavated in each cemetery.

A typical Naqada grave consisted of a vertical pit dug into the gravel shoals at the edge of the desert (Baumgartel, 1970; Petrie and Quibell, 1896). Each skeleton was placed in a contracted position, with the knees sharply bent and the hands folded across the face or neck. In almost every case, the skeleton was positioned on its left side, with the head to the south and facing west (Hoffman, 1979; Petrie and Quibell, 1896). The skeletal remains were normally accompanied by grave goods, in the form of pottery, stone palettes, and beads (Petrie and Quibell, 1896), and it is on the basis of their relative numbers and quality that social stratification has been interpreted. Items representing surplus wealth, as well as everyday goods, accompanied the burials (Bard, 1992; Hoffman, 1979).

Unfortunately, the majority of the Naqada graves were plundered in antiquity, and again following Petrie's excavations (Petrie and Quibell, 1896). Unlike many other archaeologists of the early twentieth century, Petrie used meticulous excavation and recording techniques (Bard, 1992;

Hoffman, 1979; Wenke, 1990) setting the methodological standards of Egyptian archaeology which are still followed to this day (Baumgartel, 1970; Daniel, 1975; Rice, 1990; Wenke, 1990). As a result, Petrie has been called the "doyen of modern Egyptian archaeology" (Daniel, 1975: 175). Much of what is known of the Predynastic can be attributed to his excavations and interpretations (Baines and Malek, 1980; Wenke, 1990). Petrie viewed even minor details as potentially meaningful. He claimed that "the exactness of the information is the very essence of its value" (Petrie and Quibell, 1896: viii). Petrie also enforced strict discipline among his workers. He punished them for damaging skeletal remains, for example, and "Every lad trembled in his hole...and was terrified if [Petrie] came on even a snapped rib" (Petrie and Quibell, 1896: viii). Each grave was systematically excavated by groups of laborers who were assigned tasks according to their skill level. For example, young, inexperienced workers were responsible for the initial detection of graves, while the older, more experienced workers were involved in removal of dirt from around the grave goods and skeletal remains. Petrie always recorded the contexts of the grave goods and skeletons prior to their removal.

Despite Petrie's attention to precise excavation and recording methods, he published grave good descriptions of only six percent of the Naqada tombs (Bard, 1989; Baumgartel, 1955, 1970; Davis, 1983; Hoffman, 1979; Petrie and Quibell, 1896). He reasoned that because the bulk of the material was repetitive, it was necessary to publish information on only some of the graves (Petrie, 1920). Elise Baumgartel spent much of her life recovering scattered bits of information missing from Petrie's original publication. In her supplement she provides grave good descriptions for nearly 1300 Naqada tombs (Baumgartel, 1970). According to Davis (1983: 17), she "quietly corrects numerous errors and inconsistencies" in Petrie's published site report. Baumgartel discovered that Petrie's original fieldnotes had been discarded. Fortunately, some of the notebooks were accidentally found in a box which served as a telephone stand at University College, London (Baumgartel, 1970). The missing notes helped to clarify much of the confusion surrounding particular burial numbers and grave goods.

Baumgartel's supplement provided the contexts of many graves, which aided in the identification of social stratification at Naqada. Cemetery T revealed the largest and highest status graves (Petrie and Quibell, 1896). Although Cemetery T is very small, Case and Payne (1962) demonstrated that it was used over a long period of time. Cemetery T's exclusiveness lends further support to the idea that only the elite were buried there (Case and Payne, 1962). Although Cemetery T was slightly younger than

Cemetery B and the Great Cemetery, it possessed the graves of highest status during the periods in which the three cemeteries coincided chronologically (Davis, 1983: 24). Recent studies concerning the wealth of the Naqada cemeteries have been conducted by Castillos (1981, 1982, 1983) and Bard (1989). Castillos (1982) compared the sizes of graves and the numbers of grave goods among the Naqada cemeteries. He found that Cemetery B had the smallest graves and the Great Cemetery had the least number of grave goods, whereas Cemetery T had the largest graves and the greatest proportions of funerary items. Castillos (1983) also compared average grave goods among Predynastic and Early Dynastic Egyptian sites. The average number of grave goods per tomb ranged from 3.1 at Naga ed-Der (early Predynastic) to 6.9 at Abydos (early Dynastic). The average for the combined cemeteries at Naqada was a comparable 4.5 grave goods per tomb. The Cemetery T average, however, was 14.0 which was the highest figure that Castillos reported. Bard's (1989) cluster analysis of grave good differentiation at Naqada revealed similar findings. Since Cemetery T consistently had the graves of highest status, particularly in Naqada II times, it therefore must have been a burial ground for the Predynastic elite from Naqada.

Petrie's investigations of the cemeteries and towns at Naqada were funded solely by private sponsors. Jesse Haworth and Martyn Kennard were major contributors to his studies, as was A.B. Pearson-Gee who paid for the packing and transport of the skeletons (Petrie and Quibell, 1896). Some of the material was placed in the Giza Museum, but the majority was shipped to England. The British Museum did not want the Naqada material on the grounds that it was 'unhistoric' (Daniel, 1975). Most of the grave goods were instead endowed to the Ashmolean Museum, Oxford, and the remainder were sent to other museums in England, Germany, and the United States. The skeletal remains were originally housed at University College, London, but are now located at Cambridge University, England where they form part of the Duckworth Collection.

Several studies were made possible because of the retention of Naqada human remains (e.g., Fawcett and Lee, 1901-1902; Pearson, 1896; Petrie and Quibell, 1896; Warren, 1897). Past research interests sometimes differ from those of today. Early scholars, for example, were predominantly interested in determining the race of the ancient Egyptians. Although current researchers are still interested in genetic relatedness, skeletal remains can also reveal other forms of information. For example, the study of past disease patterns can provide a more complete understanding of Predynastic Egyptian lifeways. Skeletal remains provide another source of information about behavior, an important source since texts are absent and artifactual remains are limited.

The remainder of this thesis will focus upon the association between the osteological evidence of disease and the artifactual evidence of social status in the Upper Egyptian Predynastic site of Naqada.

Table 2-1. The number of Naqada graves.

Cemetery	Approximate # of Graves
Great	2000
B	130
T	58

(Baumgartel, 1970)

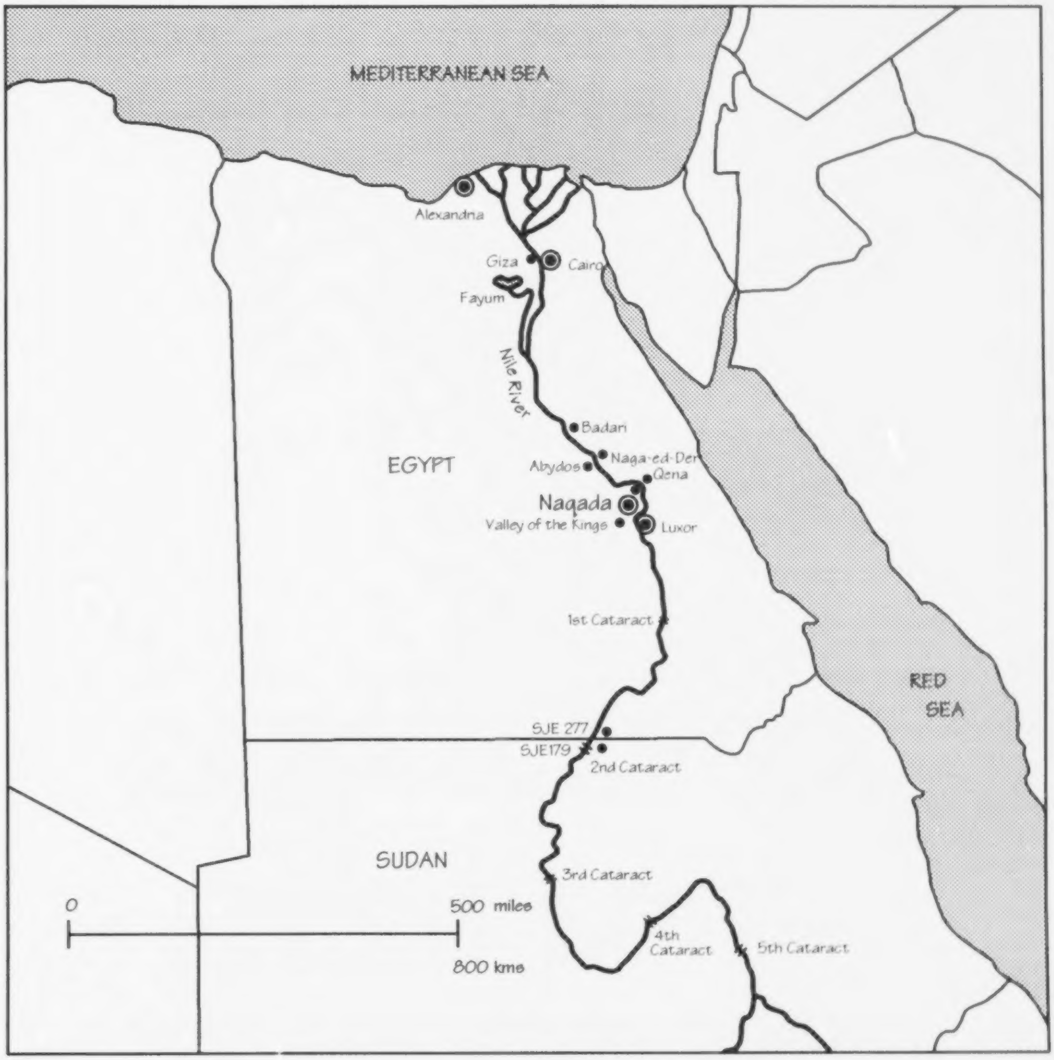
MEDITERRANEAN SEA
Alexandria
Giza
Cairo
Fayum
Nile River
Badari
Naga-ed-Der
Abydos
Qena
EGYPT
Naqada
Valley of the Kings
Luxor
1st Cataract
RED SEA
SJE 277
SJE179
2nd Cataract
SUDAN
3rd Cataract
0
500 miles
800 kms
4th Cataract
5th Cataract

Figure 2-1. Map of ancient Egypt and Nubia showing the location of Naqada and other Predynastic sites.

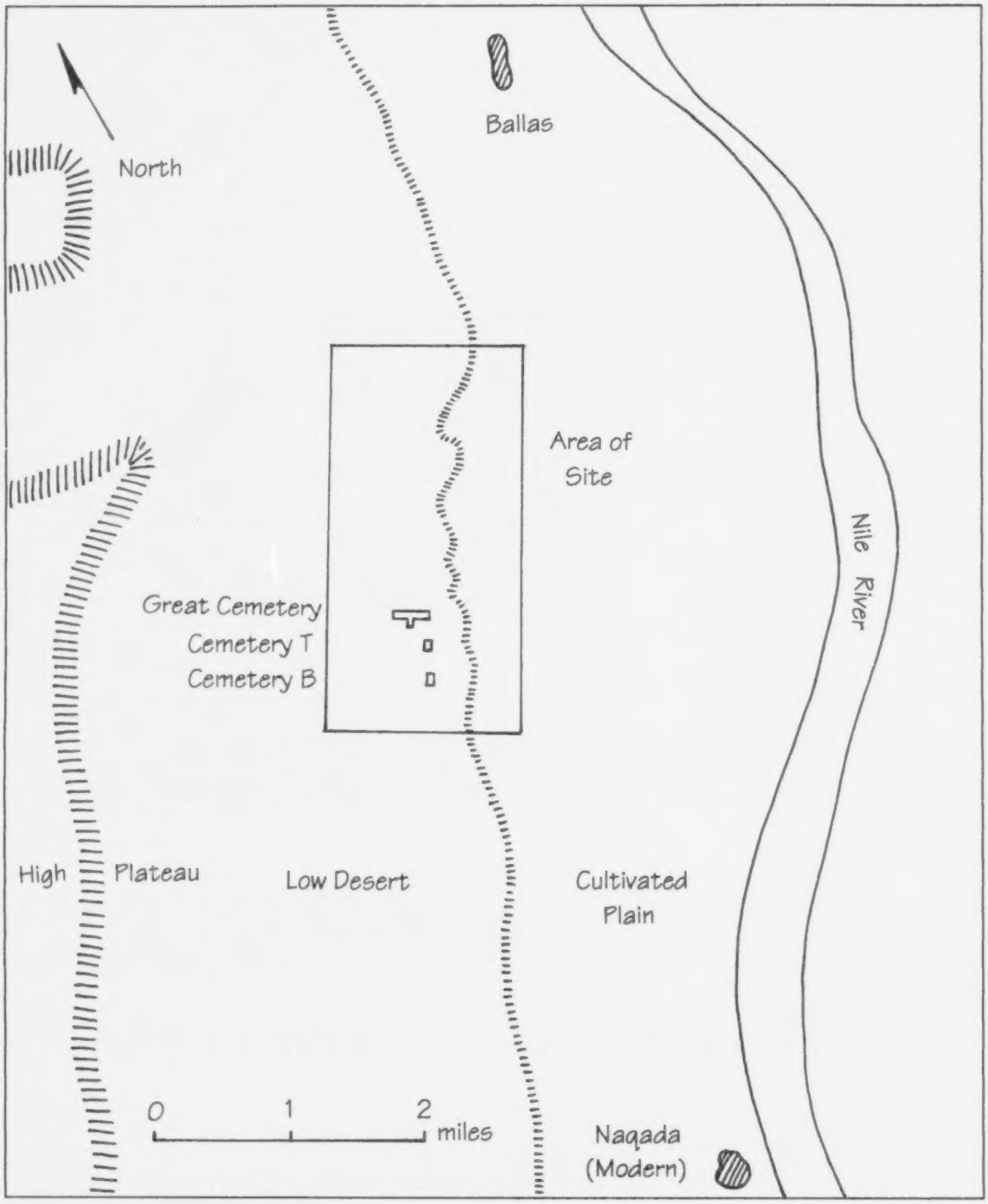
North
Ballas
Area of Site
Nile River
Great Cemetery
Cemetery T
Cemetery B
High Plateau
Low Desert
Cultivated Plain
0
1
2
miles
Naqada (Modern)

Figure 2-2. Area map of Naqada (adapted from Petrie and Quibell, 1896).

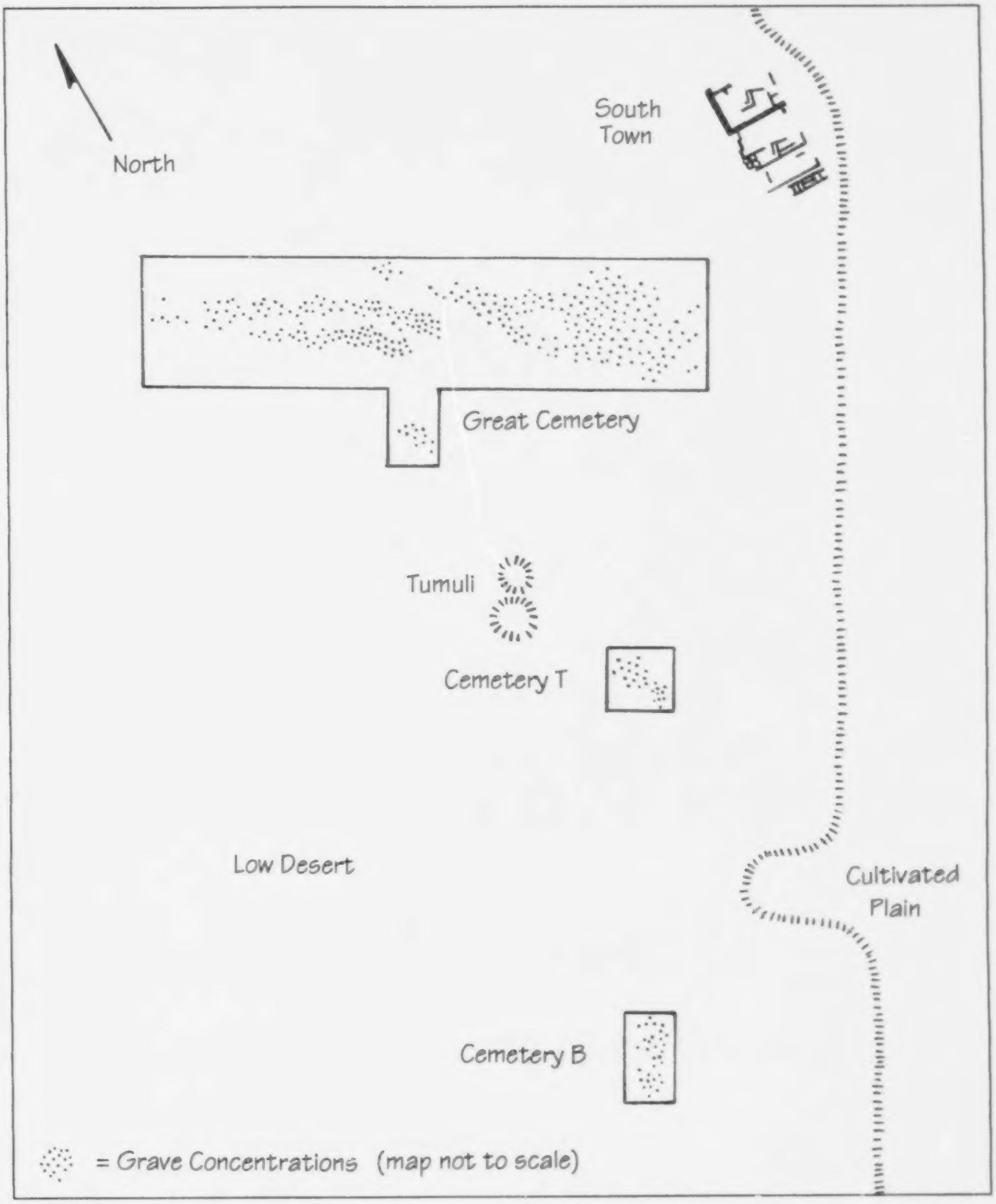
North
South Town
Great Cemetery
Tumuli
Cemetery T
Low Desert
Cultivated Plain
Cemetery B
= Grave Concentrations (map not to scale)

Figure 2-3. Site map of Naqada (adapted from Petrie and Quibell, 1896).

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Chapter 3:
MATERIALS AND METHODS

INTRODUCTION

This chapter provides a detailed description of: 1) the Naqada cranial study sample; 2) general and specific methods of palaeopathological analyses; and 3) the statistical methods utilized in this study. This discussion will form the methodological basis for the subsequent chapters that report the results.

SKELETAL MATERIALS

In 1894-1895, Sir William Matthew Flinders Petrie excavated nearly 2200 graves from the Predynastic Upper Egyptian site of Naqada (Petrie and Quibell, 1896). Not only did he recover numerous grave goods, Petrie also retained human skeletons from nearly 400 individuals (Fawcett and Lee, 1901-1902). He subsequently sent the skeletal remains to England for metric analyses. Karl Pearson (1896), Herbert Thompson (in Petrie and Quibell, 1896), and Cicely Fawcett and Alice Lee (1901-1902) measured the skulls, while Ernest Warren (1897) studied the postcranial remains. The skeletal material was originally stored at University College, London, but is now located at Cambridge University where it forms part of the extensive Duckworth Collection.

The present study sample was derived from these original skeletons and consists of 132 skulls from the Great Cemetery (n=62), Cemetery B (n=34), and Cemetery T (n=36). The sex and age distribution of these cranial remains is presented in Table 3-1. The crania were collected by Petrie for Pearson's craniometric study, so any bias was probably in favor of the better-preserved complete crania, which may explain the greater proportion of males compared to females. Most of the skulls are partially (50-90% present) to completely preserved (90-100% present), but some of the material is fragmentary. Skeletal material that lacked clear archaeological context was excluded. The sample is limited to the skulls, for example, because the postcranial bones were commingled following excavation. Although most of the long bones were labelled at the time of their discovery (Petrie and Quibell, 1896), many of the labels are no longer legible. It is therefore impossible in some cases (Warren, 1897) and impractical in all cases to reconstruct the skeletons. Similarly, the skulls uncovered by Quibell and Grenfell were not included, because Quibell, who excavated at both Naqada and at nearby Ballas, labelled his finds with a 'Q' regardless of the site at which they were discovered, and because Grenfell apparently never published his findings (Baumgartel, 1970). Definite grave contexts are lacking in many cases, because Petrie's published site report (Petrie and Quibell, 1896) is incomplete, and most of his original excavation records were discarded (Baumgartel, 1970). Despite his attention to precise excavation methods, Petrie published descriptions of only six percent of the Naqada graves (Baumgartel, 1970). Fortunately, Baumgartel (1970) recovered some of the lost Naqada records and was therefore able to alleviate at least some of the context problems.

METHODS OF PALAEOPATHOLOGICAL IDENTIFICATION AND DIAGNOSIS

Data collection for this study consisted of recording detailed written descriptions for each skull. It was necessary to determine the sex and estimate the age at death for each individual, since demographic variables often affect disease prevalence (Ortner and Putschar, 1985). These initial analyses were conducted by Marnie Bartell and Dr. Nancy Lovell in June, 1992, at the Department of Biological Anthropology, Cambridge University, England.

Although the sex of each Naqada skeleton was previously determined by G.D. Thane and Ernest Warren (Petrie and Quibell, 1896; Warren, 1897), the skulls were reanalyzed using more recent techniques. The re-estimates of sex, which did not vary greatly from the original assessments, were based on morphological features of the crania and mandibles. Female skulls are usually gracile with subtle characteristics, such as rounded chins, small mastoid processes, rounded eye orbits, and absent or poorly developed supraorbital ridges. Male skulls, on the other hand, are normally robust with well defined features, such as angular chins, large mastoid processes, squared off eye orbits, and distinctive supraorbital tori (Bass, 1987; Ubelaker, 1989; White, 1991). Sex could not be estimated when the skulls were poorly preserved or when they had ambiguous characteristics. These crania were labelled as 'Unknowns'.

Not unlike the sex estimates, the age approximations were based on observable features. Age at death was primarily established by the ectocranial suture closure method (Meindl and Lovejoy, 1985), although dental wear was used to approximate very rough ages when the sutures were unobservable. Cranial sutures may be used to estimate age, because they fuse over time at a relatively consistent rate. In subadults, for example, the sutures are open and visible, whereas in old adults they are closed and indistinct. An age estimate may be obtained by scoring an individual's sutures by degree of closure. Two groups of suture sites can be analyzed, including the less reliable but more often preserved vault sutures (midlamdoid, lambda, obelion, anterior sagittal, bregma, midcoronal, and pterion), and the more reliable but less often preserved lateral-anterior sutures (midcoronal, pterion, sphenofrontal, inferior sphenotemporal, and superior sphenotemporal) (Meindl and Lovejoy, 1985). If a pathological lesion affected a suture scoring site, it was recorded as unobservable. Systemic pathological conditions, such as craniostenosis, that affected suture development were so identified and suture closure was not used for aging. Although the cranial suture closure aging method has been the subject of controversy historically concerning its reliability and methodology, improvements have increased the usefulness of this tecnique (Meindl and Lovejoy, 1985). Also, it has been demonstrated that sex and race do not bias the effectiveness of this revised method (Meindl and Lovejoy, 1985).

Ectocranial suture closure is a relatively adequate method for aging skulls, but the Naqada cranial sutures were not always preserved. For the skulls with most of the sutures missing, ages were instead based on the degree of dental wear, providing at least some of the teeth were present. Age seriations were derived from Lovejoy's study (1985) of dental wear ages in the Libben population. Because dental wear varies greatly among populations, the Libben criteria were slightly modified in this study to account for cultural differences (N. Lovell, personal communication).

Most of the age approximations, whether they were based on ectocranial suture closure or dental wear, were represented by a range of ages, such as '41.1 ± 10.0 years', '18-24 years', and '>50 years'. In order to make sense of the variety of age estimates, the Naqada individuals were grouped into 'Young Adults' (21-30 years), 'Middle Adults' (31-40 years), and 'Old Adults' (41 years and older). The estimated ages were classified on the basis of their midpoints, because their ranges often overlapped these categories. An individual aged '30-50 years', for example, was classified as a 'Middle Adult' based on the average age of '40 years'. The classification of age estimates into broad categories accounts for possible errors while still allowing for the detection of age-related patterns (Hodges, 1991; Ubelaker, 1989). 'Subadults' (under 21 years of age) were excluded from this study due to their possible differential expression of pathological lesions. Tooth eruption and bone growth, for example, may affect the usual expression of temporomandibular joint arthritis in subadults (Carlsson et al., 1979; Dibbets and van der Weele, 1992; Sheridan et al., 1991; Wedel et al., 1978). When precise age estimates could not be made, such as in the case of very fragmentary remains, adult crania were classified as 'Unknowns'.

In addition to estimating sex and age, each skull was classified by its degree of preservation: 'incomplete' (less than 50% present), 'partial' (50-90% present), and 'complete' (90-100% present). It is important to consider completeness since it affects the likelihood of observing abnormal lesions. Fragmentary and friable conditions were also noted, because they may have obscured pathological evidence.

Following the sex and age estimates, palaeopathological lesions of the crania and mandibles were identified and differentially diagnosed using standard macroscopic methods outlined by Mann and Murphy (1990), Ortner and Putschar (1985), and Steinbock (1976). Diagnoses followed from detailed written descriptions that considered the appearance, location, distribution, and severity of observed pathological lesions.

Although the primary objective of palaeopathology is to identify and to describe carefully any evidence of abnormal bone, an understanding of typical bone and the normal range of variation is of foremost importance (Mann and Murphy, 1990; Steinbock, 1976). Bone is a living tissue comprised of an organic collagen matrix solidified mainly by calcium phosphate salts (Pritchard, 1979). The skeleton undergoes continuous remodelling to renew old bone and to adapt to the stresses placed upon it. Remodelling involves two types of bone cells: osteoclasts and osteoblasts (Pritchard, 1979). Osteoclasts resorb bone by dissolving cells, whereas osteoblasts form bone by secreting a protein matrix. Under normal circumstances, the activities of the two cell types are balanced. Pathological lesions result, however, when the normal ratios are disturbed (Steinbock, 1976). Diseases and injuries do not actually destroy bone, but instead stimulate abnormal rates of osteoclastic and/or osteoblastic activity (Ortner and Putschar, 1985). The skeleton can therefore only react in a limited number of ways (Ortner and Putschar, 1985; Rothschild and Martin, 1993; Steinbock, 1976), although abnormal rates of remodelling can affect the density, size, shape, and texture of the affected bones.

In addition to the normal range of variation, the identification of pathological bone must also be distinguished from postmortem changes (Henderson, 1987; Rothschild and Martin, 1993; Waldron, 1987). The effects of diagenesis upon skeletal remains can sometimes mimic pathological lesions (Ortner and Putschar, 1985). Through the processes of burial, decomposition, and archaeological recovery, a number of factors can alter the skeleton. Following burial, for example, the bones may be warped from soil pressure or damaged from water or chemical contamination. Skeletal remains may be also be disturbed by insects, animal scavengers, growing plants and roots, or by other taphonomic agents. Furthermore, archaeological excavation and subsequent handling can sometimes damage skeletal remains (Henderson, 1987; Rothschild, 1992; Rothschild and Martin, 1993; Waldron, 1987).

A detailed written description not only helps in distinguishing pathological bone from the normal range of variation and from taphonomic changes, but also assists in diagnosing disease and allowing for future re-interpretations (Ortner, 1991). When a pathological lesion is observed, a detailed description of its appearance should be made. The report should include whether or not the lesions are: proliferative and/or resorptive, superficial and/or penetrating, unremodelled and/or remodelled, localized and/or diffuse, single or multiple, and minimal, moderate, or severe. In addition to describing which bones are affected, it is necessary to indicate which ones are present and absent, since the distribution of the lesions throughout the skeleton is crucial to the diagnosis of disease. When skeletal remains are incomplete or very fragmentary, it may be difficult to identify specific disease conditions. Information on the location of the observed pathological lesions should include whether or not the lesions affect the articular surface, articular margin, and/or non-articular surface, the proximal, midshaft, and/or distal ends, and the medial, lateral, superior, and/or inferior surfaces.

Following the identification of lesions, the subsequent goal of palaeopathology is to determine the possible causes of these observed abnormalities, although cause of death cannot normally be determined (Ortner and Putschar, 1985). The identification of disease conditions is sometimes made difficult by the limited response of bone, because different illnesses and injuries can produce similar lesions (Ortner and Putschar, 1985). However, by regarding the pathological evidence within a biocultural context, the detection of specific disease processes is often possible. In the interpretation of pathological evidence, the number of potential etiologies can be reduced by considering individual, environmental, and cultural factors. An affected individual's age, sex, and associated diseases may help in the interpretation of disease conditions. In modern clinical medicine, for example, breast cancer is considerably more frequent in females. The environmental context, including geography and climate, is also important. The manifestation of treponemal disease, for example, is related to the climate. Yaws is largely restricted to hot and humid climates, whereas endemic syphilis is more commonly observed in savannah or desert areas, and venereal syphilis predominates in temperate locations (Ortner and Putschar, 1985; Steinbock, 1976). Finally, cultural factors such as diet, subsistence, division of labor, and social differentiation are also crucial in the interpretations of disease (Armelagos et al., 1980; Manchester, 1987; Rothschild and Martin, 1993; Waldron, 1987).

The analysis of pathological conditions based on macroscopic evidence may also provide additional sources of information (Ortner and Putschar, 1985). Some examples include histological and radiological examinations; analyses of DNA, blood groups, trace elements, and stable isotopes;

and specialized studies including CAT scans, magnetic resonance imaging, and three-dimensional imaging (e.g., Katzenberg, 1992; Klepinger, 1992; Rothschild, 1992; Sandford, 1992; Stout, 1992). Although such information is valuable, these methods were not used for the present analysis of the Naqada material due to several logistic constraints. First, most of these studies are time consuming and require specialized and expensive equipment. Second, some tests, such as microscopic and chemical analyses, may damage the skeletal material (Ortner and Putschar, 1985). The Naqada remains are limited, so it is not justifiable to damage them further. Third, chemical studies may also be subject to contamination by the burial environment (Ortner and Aufderheide, 1991). And finally, although radiology does not destroy bone, the x-rays of skulls are often difficult to interpret because their various three-dimensional levels are superimposed on two-dimensional images (Ortner and Putschar, 1985).

The study of illnesses and injuries in antiquity is possible because evidence is often preserved and directly observable in skeletal remains (Pfeiffer, 1991). It is essential, however, to recognize the potential problems and limitations of palaeopathology in general (Rothschild and Martin, 1993).

The first problem concerns an apparent lack of standardized methods and theories (Ortner, 1991; Ortner and Aufderheide, 1991). Over the course of its development, palaeopathology has transformed from a descriptive study of anatomical oddities at the individual level to a problem-based examination of conditions at the population level (Armelagos, 1969). Although strict protocols for disease identification and interpretation have yet to be established, detailed description remains fundamental to the discipline since it provides a basis for statistical comparisons and permits future re-interpretations.

Another problem affecting palaeopathology is its relationship to modern medicine. Palaeopathological diagnoses are often based on analogies to modern medical conditions, but, unlike clinical medicine, palaeopathology cannot rely on disease symptoms observed in living patients (Manchester, 1987; Ortner and Putschar, 1985; Pfeiffer, 1991). There are also a number of problems associated with relating current conditions to past evidence. First, diseases change over time (Manchester, 1987; Ortner and Aufderheide, 1991; Ortner and Putschar, 1985), therefore skeletal responses in the past may be different than those seen in the present (Ortner, 1991). Treponemal disease, for example, has transformed from a skin condition to a venereal disease (Hudson, 1965). Second, some diseases no longer exist or are very infrequent (Ortner, 1991), such as English sweating sickness and smallpox. Alternatively, there are current diseases, such as Acquired Immune Deficiency

Syndrome (AIDS), that have only recently developed. Third, only a limited number of conditions actually affect the skeleton (Manchester, 1987; Wood et al., 1992). Skeletal changes usually only occur as a result of chronic conditions, and are often secondary to diseases established elsewhere in the body (Wood et al., 1992). A lack of skeletal evidence therefore does not necessarily indicate that the individuals were healthy or unaffected by disease, since they may have suffered from acute illnesses or died prior to the manifestation of the conditions in their skeletons (Ortner and Putschar, 1985; Wood et al., 1992). The appearance of pathological lesions may therefore represent a healthy immune response in which the affected individuals survived long enough for skeletal changes to develop (Ortner, 1991; Ortner and Aufderheide, 1991; Wood et al., 1992). Another complicating factor is that some diseases may be beneficial (Ortner and Aufderheide, 1991). The genes which cause sickle-cell anemia, for example, help to reduce the effects of malaria in heterozygous individuals (McElroy and Townsend, 1989; Steinbock, 1976).

Despite its limitations, evidence of pathological lesions in skeletal remains is still valuable. The presence of abnormalities are at least suggestive of past diseases and injuries. Important information about behavior and culture can be derived by considering the skeletal evidence within its biocultural context at the population level (Chapman and Randsborg, 1981). Social status, for example, likely had an effect on the exposure and immune response of individuals to certain diseases and injuries in the past (Manchester, 1987: 176).

METHODS OF DATA ANALYSIS

The statistical analysis of the diseases observed in the Naqada cranial remains consisted of a series of tests aimed at identifying intra- and inter-cemetery patterns. Statistics were only used to analyze individuals of known sex and age (e.g., 'Unknowns and 'Adults' were excluded), and the most prevalent conditions.

The pathological descriptions were converted into numerical codes for statistical manipulation. Each condition was scored as 'present', 'absent', or 'unobservable' per individual. Although it was initially described, the severity of the lesions was not coded for analysis because of the small sample sizes. Temporomandibular joint arthritis was scored as 'present' when at least one of the mandibular fossae or mandibular condyles exhibited lesions. Similarly, cribra orbitalia was considered 'present' when at least one of the orbits was affected, and porotic hyperostosis of the vault was 'present' when lesions were observed on at least one of the frontal, parietal, or occipital bones. The coded information was entered into an Excel spreadsheet, version

3.0 for the Macintosh, and was imported into Systat, version 5.2.1 for Macintosh computers, for subsequent statistical analyses.

Prior to examining the relationship between disease prevalence and social stratification, it was necessary to identify any additional factors that may have contributed to the lesion frequencies. It was possible, for example, to rule out the effect of side in the expression of bilateral conditions. The frequencies of temporomandibular joint arthritis in the left mandibular fossae and condyles were associated with those in the right side (Fisher's Exact test, $p<0.001$). The left and right orbits affected by cribra orbitalia were also associated with one another (Fisher's Exact test, $p<0.001$). It was therefore possible to pool the left and right sides when analyzing these conditions further. Although they are both thought to result from anemia (Ortner and Putschar, 1985; Steinbock, 1976; Stuart-Macadam, 1989), porotic hyperostosis of the vault and orbits could not be pooled because their frequencies were not associated (χ^2, $p=0.354$). It was also necessary to maintain the demographic variables, because the prevalence of osteoarthritis and anemia are normally age and sex dependent (Jurmain, 1991; Ortner and Putschar, 1985; Waldron, 1991).

After considering the effects of side, disease associations, and age and sex, an attempt was made to correlate health with social status by comparing disease frequencies between the cemeteries. Three different statistical tests were used for the comparisons including the chi-square test, the chi-square test with Yate's correction for continuity, and the Fisher's Exact probability test. Their formulae are listed in the Appendix. Normally, the standard chi-square test is adequate for detecting significant differences among categorical data (Blalock, 1979; Siegal and Castellan, 1988). In the case of the Naqada cranial material, however, small sample sizes often necessitated the use of alternative test statistics. Limited samples sizes were unavoidable because cemeteries B and T are both represented by a small number of graves. Additionally, cell sizes were lowered when controlling for the effects of age and sex. Because of their potential influence on the disease frequencies, it was necessary to consider the demographic variables along with social status simultaneously.

The chi-square test could only be used for the analyses of large subsamples (Blalock, 1979; Cochran, 1954; Freeman, 1987; Siegal and Castellan, 1988). A substantial number of cases is required for the sampling distribution X^2, based on categorical data, to approximate the true distribution χ^2 properly, based on infinite data (Blalock, 1979; Cochran, 1954; Siegal and Castellan, 1988). The corrected chi-square test and the Fisher's Exact test were used to interpret small and very small subsamples respectively. The three statistical tests are comparable since they produce similar probability values.

When sample sizes are small, the corrected chi-square test is more precise than the uncorrected version for approximating the test statistic. The continuity correction is not necessary for larger samples since they tend to behave more like continuous distributions (Blalock, 1979). Although differing opinions exist, it is generally agreed that Yate's correction should be applied to 2x2 tables when at least one expected value falls below ten, and to RxC tables when more than two of the expected values fall below five (Blalock, 1979; Thomas, 1986).

The Fisher's Exact test is adequate for comparing very small sample sizes in which at least one expected value is less than five (Rosner, 1990). However, it is only applicable to 2x2 contingency tables. As a result, it is sometimes necessary to combine related variables to ensure 2x2 comparisons (Blalock, 1979; Siegal and Castellan, 1988). In the present study, the data obtained from Cemetery B and the Great Cemetery were combined on the basis of their archaeological (Baumgartel, 1970) and genetic similarities (Johnson and Lovell, 1994). Thus, comparisons of very small subsample sizes were possible. To maintain consistency, the B and Great Cemeteries were combined for all analyses regardless of the test statistic used, and as a result, comparisons were made between the 'low status' and 'high status' cemeteries.

As was mentioned previously, age and sex were controlled to minimize their influence upon the results. There are a number of ways in which to deal with such extraneous variables. Methods normally used in other anthropological studies, such as ignoring the effects of extra factors (Rudney, 1983), testing for variables one at a time (Sheridan et al., 1991), and using multivariate techniques (Hodges, 1991), were not appropriate for this study. Instead, the additional variables were simultaneously controlled.

It was not possible, for example, to ignore the effects of age and sex when testing for disease frequency differences. Because the demographic profiles were not equivalent between the cemeteries, variable disease patterns may have been attributable to age and sex differences instead of to predicted dissimilarities based on social status as outlined in Chapter 2. Sample size is often large enough to ensure similar demographic patterns between different groups enabling the factors of age and sex to be disregarded (Kerlinger, 1986). In a study of molar growth disturbance indicators, for example, Rudney (1983) was able to rule out age as a factor because of similar distributions between the Meroitic and X-Group Nubians. Sample sizes were too small, however, to ensure similar demographic patterns among the Naqada crania, and, as a result, it was not possible to ignore such variables.

Alternatively, some studies deal with additional variables one at a time. For example, ages are pooled when testing for sex differences, and similarly sexes are combined when looking for variations due to age (e.g., Sheridan et al., 1991). Although this method avoids small sample sizes, it is risky because there is a potential loss of information (Blalock, 1979) and also a danger of obtaining inconsistent results (Fingleton, 1984; O'Brien, 1989; Simpson, 1951; Upton, 1986). This situation is known as Simpson's Paradox (after Simpson, 1951). Errors are possible when a contingency table formed by more than two variables is divided into smaller subtables for separate analyses, because associations may be eliminated or inverted (Fingleton, 1984; O'Brien, 1989). When sexes are pooled, for example, a positive association among females could cancel out a negative association among males.

In order to avoid Simpson's Paradox, multivariate techniques have been suggested (Freeman, 1987; O'Brien, 1989; Upton, 1986). Loglinear analysis, for example, develops a numerical model to explain the relationships among multiple categorical variables (Freeman, 1987; O'Brien, 1989). However, such methods are not appropriate for this study, because they often rely on the standard chi-square method to test for statistical significance and are therefore subject to the large sample size assumption previously discussed (Freeman, 1987). It has been suggested that multivariate techniques should be avoided (Lock, 1991) because of the difficulty in interpreting and validating the results (Freeman, 1987). Lower level statistical tests are often preferable because they can pick out "quite subtle relationships" (Lock, 1991: 91) that are otherwise missed by the more generalized multivariate methods.

The concern over the effects of extraneous variables was justified given the possibility of obtaining paradoxical results. For this study, therefore, it was necessary to examine the significant relationships while avoiding Simpson's Paradox. The cemetery demographic profiles were too different to ignore age and sex variables or to test them one at a time, and sample sizes were too small to use multivariate techniques. Instead, the extra variables of age and sex were simultaneously controlled (Blalock, 1979). This was accomplished by holding the extraneous variables at constant values while testing for relationships among the primary variables (e.g. social status). This process was repeated for every possible expression of the control variables (Blalock, 1979). With respect to the Naqada material this entailed examining disease frequency differences between the cemeteries for all possible combinations of the age and sex categories: young adult females, young adult males, middle adult females, and so on. This technique "not only provides a more rigorous test of an hypothesis, but it may also lead to additional insights" (Blalock, 1979: 318). Furthermore, Simpson's Paradox is effectively avoided.

The disadvantage in dealing with additional variables in this manner is that small subsample sizes result (Blalock, 1979). Although the corrected chi-square method and Fisher's Exact test are able to deal adequately with small numbers, a very strong relationship is required to obtain significant results (Blalock, 1979; Freeman, 1987). Nonetheless, if significance is obtained with smaller samples, the relationships are much more meaningful than for those resulting from larger samples (Blalock, 1979).

To compensate for the difficulty in obtaining meaningful results, it is not unreasonable to have generous significance levels for very small samples (Thomas, 1986). Therefore, the alpha levels for this study were set at 0.05 for the standard and corrected chi-square tests, and at 0.10 for the analyses involving the Fisher's Exact test. The amounts were established simply as guidelines since statistical significance does not necessarily equate to archaeological significance (Lock, 1991; Thomas, 1986; Upton, 1986). In all cases the actual p-values are reported so that anyone can judge whether or not the results are significant (Siegal and Castellan, 1988). As suggested by Blalock (1979), indices of association representing the strength of the relationships were not reported because significant differences were rarely encountered.

In conclusion, although this study was faced with numerous difficulties associated with small sample sizes, relationships between the variables were effectively tested. This was accomplished by combining the B and Great cemeteries and systematically applying the chi-square, corrected chi-square, and Fisher's Exact tests to the Naqada data while controlling for the extraneous variables of age and sex. The results, however, should be accepted with some caution. The validity of the interpretations rests upon the representativeness of the sample. As with most skeletal samples, it is difficult to assume that the dead are completely representative of the once-living (Boddington, 1987; Roth, 1992; Wood et al., 1992) "given all the non-random events that surrounded death and burial" (Waldron, 1991: 24). Additional problems specific to the Naqada sample include the small number of cases, the confused grave contexts in some instances, and the disturbance by looters of many of the graves prior to excavation. Nonetheless, meaningful interpretations of the Naqada disease data were made possible by keeping these limitations in mind.

Table 3-1. Age and sex distribution of the Naqada cranial remains.

Sex and Age	Cemetery B		Great Cemetery		Cemetery T		Totals	
	#/n	%	#/n	%	#/n	%	#/n	%
Females								
Young Adults	3/8	37.5	4/21	19.0	1/16	6.3	8/45	17.8
Middle Adults	1/8	12.5	7/21	33.3	8/16	50.0	16/45	35.6
Old Adults	4/8	50.0	10/21	47.6	5/16	31.3	19/45	42.2
Adults	0/8	0.0	0/21	0.0	2/16	12.5	2/45	4.4
Males								
Young Adults	2/20	10.0	5/41	12.2	0/20	0.0	7/81	8.6
Middle Adults	10/20	50.0	15/41	36.6	6/20	30.0	31/81	38.3
Old Adults	8/20	40.0	19/41	46.3	11/20	55.0	38/81	46.9
Adults	0/20	0.0	2/41	4.9	3/20	15.0	5/81	6.2
Unknowns								
Young Adults	0/6	0.0	0/0	0.0	0/0	0.0	0/6	0.0
Middle Adults	2/6	33.3	0/0	0.0	0/0	0.0	2/6	33.3
Old Adults	4/6	66.7	0/0	0.0	0/0	0.0	4/6	66.7
Adults	0/6	0.0	0/0	0.0	0/0	0.0	0/6	0.0
Totals								
Young Adults	5/34	14.7	9/62	14.5	1/36	2.8	15/132	11.4
Middle Adults	13/34	38.2	22/62	35.5	14/36	38.9	49/132	37.1
Old Adults	16/34	47.1	29/62	46.8	16/36	44.4	61/132	46.2
Adults	0/34	0.0	2/62	3.2	5/36	13.9	7/132	5.3

Note: '#' = number of individuals within the subsample; 'n' = total number of individuals; '%' = percentage of individuals within the sample.

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Chapter 4:
SKELETAL EVIDENCE OF DISEASE AT PREDYNASTIC NAQADA, EGYPT[1]

INTRODUCTION

Social stratification in an archaeological site is normally identified by artifacts and features, but skeletal remains can also provide important information. Because social position can affect an individual's exposure to pathogens and injuries, disease patterns preserved in human bony remains may be indicative of status. Modern analogies, for example, suggest that people of lower status are more likely to suffer from conditions associated with inadequate sanitation, poor hygiene, heavy work loads, and malnutrition than are people of higher status. The purpose of this study is therefore to illustrate the usefulness of skeletal analysis in the interpretation of complex societies. An examination of the association between the osteological evidence of disease and the artifactual evidence of social status in the Upper Egyptian Predynastic site of Naqada will be provided.

The Predynastic period, dating from approximately 4000 B.C. to 3000 B.C., is often overshadowed by the later Dynastic era of Egyptian history (Arkell, 1975; Kemp, 1977; Rice, 1990; Trigger, 1983), which is well known for cultural remains such as the mummies of the Pharaohs, the pyramids at Giza, and the tombs in the Valley of the Kings (Anderson, 1983; Baines and Malek, 1980; Malek, 1983). The Predynastic period, however, represents the roots of Egyptian civilization (Bard, 1992). State organization did not suddenly appear at the beginning of the First Dynasty, but was instead undergoing a continuous development from Predynastic times (Baines and Malek, 1980; Bard, 1987; Hassan, 1988; Rice, 1990; Trigger, 1983). A complete understanding of ancient Egypt therefore requires an appreciation of both the Dynastic and Predynastic phases (Arkell, 1975; Baines and Malek, 1980).

This study is based on skeletal remains from the Upper Egyptian site of Naqada, located approximately 25 kilometres northwest of the Valley of the Kings (Baines and Malek, 1980; Bard, 1987; Baumgartel, 1970; Petrie and Quibell, 1896). The site was excavated by Sir Flinders Petrie in 1894-95 (Petrie and Quibell, 1896) and is significant for several reasons. Not only was Naqada the first Predynastic site ever discovered (Baumgartel, 1955; Hassan, 1988), it is also one of the largest found so far, boasting nearly 2200 graves (Bard, 1987, 1989, 1992; Baumgartel, 1955, 1970;, 1993.Hoffman, 1979; Petrie, 1931). Further, it is one of the most important sites for an understanding of early Egypt since the cultural chronology of the Upper Egyptian Predynastic period was largely derived from Petrie's sequence dating method, which he developed using the Naqada pottery styles (Baumgartel, 1970; Hoffman, 1979; Petrie, 1901, 1920; Wenke, 1990). Finally, Naqada seems to provide evidence of the origins of social stratification in Egypt that foreshadows the development of rule by divine kingship (Bard, 1992; Hoffman, 1979).

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On the basis of the grave goods and grave dimensions, archaeologists have identified social status differences in three relatively contemporaneous cemeteries at Naqada (Bard, 1989, 1992; Baumgartel, 1970; Case and Payne, 1962; Castillos, 1981, 1982, 1983; Davis, 1983; Kemp, 1973; Petrie and Quibell, 1896). Although the majority of the Naqada graves had been plundered in antiquity (Petrie and Quibell, 1896) and the published records dealing with artifact provenience are incomplete (Bard, 1989; Baumgartel, 1955, 1970; Davis, 1983; Hoffman, 1979; Petrie and Quibell, 1896), evidence of social stratification at Naqada is apparent. Individuals of higher status were interred in Cemetery T, whereas people of lower status were buried in Cemetery B and the Great Cemetery. Castillos (1983) determined that the average number of grave goods per Naqada tomb (cemeteries combined) was 4.5, while the average number per Cemetery T grave was 14.0.

The purpose of analyzing the skeletal disease patterns was therefore to test for the consequences that social stratification had upon the ancient Egyptians of Naqada.

MATERIALS AND METHODS

The study sample consisted of 132 skulls derived from Cemetery B (n=34), Cemetery T (n=36), and the Great Cemetery (n=62). The postcranial bones were not examined because they were commingled following excavation, and, as a result, it is impossible in some cases (Warren, 1897) and impractical in all cases to piece the skeletons back together. The cranial remains were analyzed in June of 1992 at Cambridge University, England, where they are currently located and form part of the Duckworth Collection.

Petrie collected the crania for Pearson's craniometric study. As a result, any bias was likely in favor of the well-preserved complete crania. There is no indication that the cranial remains were collected with reference to the presence or absence of pathology. The skulls were generally well preserved and in good condition. Although age and sex were originally assessed in a craniometric study in the early 1900's (Fawcett and Lee, 1901-1902), these demographic variables were reestimated using more recent morphological techniques (Bass, 1987; Meindl and Lovejoy, 1985; Ubelaker, 1989; White, 1991). Individuals were classified by sex and by age groups, such as Young Adults, Middle Adults, and Old Adults. Subadults were excluded from this study. Skulls for which sex or age could not be estimated, such as those which were incompletely preserved, were labelled as 'Unknowns' and were excluded from statistical analyses involving sex or age respectively.

Palaeopathological lesions were identified through visual observation and reference to standard works such as Ortner and Putschar (1985) and Steinbock (1976). Differential diagnoses were formed based on the appearance, location, and severity of the observed lesions. Diseases of the teeth were also assessed, but this paper is limited to the bony conditions.

Disease percentages were compared among the Naqada cemeteries in an attempt to correlate health with social status. To help alleviate the small sample size problem, the disease frequencies of Cemetery B and the Great Cemetery were combined based on their archaeological and genetic similarities (Johnson and Lovell, 1994). Thus, the pooled lower status individuals were compared with the higher status individuals.

It was important to control for the possible effects of age and sex because the Naqada cemeteries had different demographic profiles. Disease frequencies were compared between the status groups for each possible combination of the age and sex classifications. Depending upon the subsamples sizes, p-values were calculated from one of three statistical tests: the standard chi-square test of independence, the Yate's Corrected chi-square test, and the Fisher's Exact test. The small Naqada samples did not allow the use of multivariate tests, such as loglinear analysis (Freeman, 1987, O'Brien, 1989), which could have simultaneously considered the variables of age, sex, and cemetery.

RESULTS AND DISCUSSION

In general, the skulls revealed relatively few pathological lesions. There was no evidence of tuberculosis, syphilis, leprosy, tumors, or fractures in the skulls from any of the cemeteries at Naqada. Biparietal thinning, localized infection, and arthritis of the atlanto-occipital joint were observed, but in very low frequencies. Temporomandibular joint arthritis and anemia, on the other hand, commonly affected the people of Naqada.

Biparietal Thinning

Biparietal thinning refers to rounded depressions of the parietal bones which affect the normal outer contour of the cranium (Bianco and Ascenzi, 1993; Brothwell, 1967; Camp and Nash, 1944; Lodge, 1967; Steinbach and Obata, 1957). The depressed lesions are usually bilateral, symmetrical, and located in the central to posterior parietals, adjacent to the sagittal suture (Camp and Nash, 1944). The thinness results from a reduced diploic layer which becomes progressively thinner towards the centre of the depression (Bianco and Ascenzi, 1993; Camp and Nash, 1944; Dutta, 1969). Unlike the outer table and the diploë, the inner table is rarely affected (Bianco and Ascenzi, 1993; Camp and Nash, 1944). The etiology of biparietal thinning is not yet firmly established. Osteoporosis (Epstein, 1953; Steinbach and Obata, 1957) and congenital defects (Camp and Nash, 1944; Steinbach and Obata, 1957) have been proposed as underlying conditions, but a recent histological study failed to identify osteoporosis as a condition common to different crania that exhibited the bilateral depressions (Bianco and Ascenzi, 1993). Despite its elusive etiology, biparietal thinning was scored for the Naqada skulls since other ancient Egyptian examples of the condition have been reported (Bianco and Ascenzi, 1993; Lodge, 1967).

Biparietal thinning was observed in only six of the 132 skulls from Naqada. The frequencies, as a result, were too small to analyze beyond a basic descriptive level. However, potential patterns were distinguishable. Cemetery T had a slightly higher prevalence of bilateral depressions. The lesions were only seen in middle to older adults, and females were affected twice as often as males. This trend is consistent with past suggestions that biparietal thinning is a disease of older females (Camp and Nash, 1944), although the condition also has been observed in younger ages and in both sexes. Perhaps more importantly, the Naqada examples of biparietal thinning indicate that the condition was not limited to Dynastic times.

Localized Infection

Only one case of infection was observed in the Naqada skulls. The lesion is a small concentration of tiny pits perforating the outer vault along the midline and directly inferior to the inca bone in an old adult male skull from Cemetery B. The precise cause is unknown since the lesion is generalized in nature, but it may have been secondary to an infection of the scalp.

Arthritis

In the Naqada cranial material arthritis was examined in the two types of skull joints: the atlanto-occipital joint and the temporomandibular joint.

The atlanto-occipital joint is formed between the occipital condyles at the base of the skull and the superior articular facets of the atlas vertebra. Since the Naqada vertebrae were not sorted by individual, they could not be matched with the crania and therefore were not examined. Thus, it was difficult to analyze the frequencies of atlanto-occipital arthritis, and as a result only simple percentages were calculated. It appears that occipital condyle arthritis increased from middle adults (11.4%) to old adults (14.6%). In a similar study of Christian, Meroitic, X-Group, and Mesolithic Nubian skulls (Armelagos, 1969) variable frequencies of occipital condyle arthritis were also attributed to age differences. The exact cause of such lesions is not clear since many factors, such as acquired or genetic disorders, trauma, and inflammation, can result in degenerative joint changes (Ortner and Putschar, 1985).

The temporomandibular joint (TMJ) is formed between the mandible and the skull. Bony evidence of arthritis in the mandibular fossae of the temporal bone or on the mandibular condyles can include erosions and lipping due to the degeneration of cartilage and the remodelling of underlying bone (Bates et al., 1993; McNeill, 1993; Ortner and Putschar, 1985). The arthritic changes in the Naqada remains were often located on the articular eminence anterior to the mandibular fossa. This is commonly reported in the clinical literature (Bates et al., 1993; Iacopino and Wathen, 1993; McNeill, 1993), and is associated with the protraction of the mandible during mastication.

The causes of TMJ arthritis are not completely understood (Bates et al., 1993; Iacopino and Wathen, 1993; McNeill, 1993; Moffett et al., 1964; Parker, 1990), but it is generally agreed that mechanical overloading of the joint may result in arthritic changes (Iacopino and Wathen, 1993; McNeill, 1993). Joint overload is thought to be related to trauma, maladaptive anatomy, systemic conditions such as neurologic and infectious disorders, and congenital abnormalities (Bates et al., 1993; McNeill, 1993), as well as the cumulative effects of aging (Bates et al., 1993). Bruxism, or teeth grinding, is often cited as a factor in modern clinical cases of TMJ arthritis and extensive tooth wear may also be a contributing factor.

Temporomandibular joint arthritis was commonly seen in the skulls from Naqada, and appears more frequently than in other skeletal samples (Table 4-1). Australian aborigines have a very high frequency of TMJ arthritis. This is likely due to their extreme tooth wear that resulted from the very high demands placed upon their masticatory systems (Richards, 1990; Richards and Brown, 1981). Female Sadlermiut Inuit, in comparison to male Inuit, have nearly twice the frequency of arthritis. This may be attributed to a sexual division of labor in which females soften skins and boots with their teeth (Merbs, 1983). The Nubians who shared a similar environment with the Egyptians reveal a much lower frequency than the people from Naqada, but this may be due to temporal differences, since the Nubian example is from a later time period.

The high frequencies of temporomandibular arthritis at Naqada may be partially due to contamination of the food by desert sand, as was suggested by Leek (1972). Coarse diets would have increased dental attrition, which at the very least, would have magnified arthritic effects in the temporomandibular joint. Grit may have also been introduced into the diet through the stone grinding of cereal grains for bread, which has long been an Egyptian dietary staple.

No statistically significant differences in the frequencies of TMJ arthritis were found when the status groups at Naqada were compared. This suggests that social status, if it existed, did not affect the factors responsible for temporomandibular arthritis.

Porotic Hyperostosis

In addition to arthritis of the temporomandibular joint, porotic hyperostosis of the vault and orbits were also commonly observed in the skulls from Naqada. The precise cause of porotic hyperostosis has been debated, but it is generally agreed that the skeletal lesions are indicative of acquired or genetic anemia (Angel, 1966; Carlson et al., 1974; El-Najjar et al., 1976; Hengen, 1971; Lallo et al., 1977; Mensforth et al., 1978). Anemia, which can affect growth, maturation, and work capacity, results from a deficiency in iron due to reduced levels of hemoglobin or red blood cells (Stuart-Macadam, 1992). Anemia may be caused by genetic disorders, such as thalassemia and sickle cell anemia (Ortner and Putschar, 1985; Steinbock, 1976; Stuart-Macadam, 1992), or may be acquired. Acquired iron deficiency anemia may result from excessive blood loss due to gastrointestinal parasites (Steinbock, 1976), infections which limit normal iron stores (Mensforth et al., 1978; Palkovich, 1987; Stuart-Macadam, 1992), malaria in which the parasite destroys red blood cells, or from an inadequate dietary intake of iron (Palkovich, 1987; Steinbock, 1976). Anemia may also occur under circumstances in which the demand for iron is higher than usual. For example, anemia most often affects children and pre-menopausal women, due to their increased need for iron for growth and pregnancy respectively (Mensforth et al., 1978; Stuart-Macadam, 1992).

Red bone marrow is stimulated to produce more red blood cells in individuals affected by anemia. The resulting pressure from the expansion of marrow can lead to the destruction of the outer surface of the bone. It is generally agreed that erosive lesions of the skull, known as porotic hyperostosis, are characteristic of anemia (Ortner and Putschar, 1985; Steinbock, 1976; Stuart-Macadam, 1985, 1989, 1992). Macroscopically, porotic hyperostosis is seen as destructive pitting of the outer bony surfaces of the cranial vault, particularly the posterior parietals, and of the orbital roofs (Stuart-Macadam, 1985, 1989, 1992). The orbital lesions are often referred to specifically as cribra orbitalia (Steinbock, 1976; Stuart-Macadam 1985, 1989).

Although both the vault and orbital lesions are thought to be the result of anemia, their precise relationship is ambiguous (Ortner and Putschar, 1985; Steinbock, 1976; Stuart-Macadam, 1989) because the two types of lesions are not always associated. Furthermore, it remains unclear whether or not skeletal lesions from acquired anemia and genetic anemia can be differentiated (Lovell, in press).

Porotic hyperostosis was frequently observed in the Naqada remains. The proportion of cranial vaults affected by anemia was generally higher than the frequency of anemia in the orbits (Tables 4-2 and 4-3). This pattern is consistent with Lovell's recent study (in press) which considered evidence of anemia in Predynastic skulls from Badari, Keneh, Naqada (Great Cemetery only), and Nubia. Although the presence of porotic hyperostosis of the vault is not statistically associated with the presence of orbital lesions, both types of lesions revealed similar patterns with respect to age, sex, and cemetery. For example, the frequencies of anemia did not increase with age for either the vault or orbital lesions. Middle adult females had much higher proportions of anemia than did middle adult males, which was statistically significant in the case of cribra orbitalia in the lower status cemeteries (Table 4-2). The frequencies of anemia in young and old adults, on the other hand, were more similar between the sexes.

Unlike the other diseases observed in the skulls, anemia was possibly associated with social status at Naqada. Middle adult females from the combined Great and B Cemeteries revealed a very high frequency of porotic hyperostosis, which is significantly larger than the prevalence for middle adult females from Cemetery T (Table 4-3). The low status middle adult females also had a higher percentage of cribra orbitalia than did the high status middle adult females, although the difference between them was not statistically significant.

The overall high frequency of anemia at Naqada is likely related to environmental factors. The Nile-dominated geography of Egypt allowed for the cultivation of cereal grains which formed the basis of the diet. Cereal grain phytates, however, inhibit the absorption of iron which may have contributed to the rates of anemia observed at Naqada, although the role of diet as a cause of iron deficiency anemia has recently been downplayed (Stuart-Macadam, 1992). The Nile River habitat is also responsible for high rates of parasitic and bacterial infections among Egyptians. Schistosomiasis, for example, is a common infection of modern Egyptians and may have affected ancient Egyptians as well (Lovell, in press). Such infections result in interstitial or urinary blood loss which can cause iron deficiency and ultimately anemia in those affected. The patterns of porotic hyperostosis specific to middle adult females from Naqada may be explained in part by the added demands for iron required by pregnancy. This need for more iron would have placed an extra strain on pregnant females who may have already been iron deficient due to diet or infection. As a result, they may have been especially prone to developing anemia.

The frequencies of porotic hyperostosis at Naqada are also consistent with Stuart-Macadam's (1985) proposal that these lesions represent a childhood condition. If skeletal lesions occurred at any age then one would expect to see an increase in their frequency with age due to the additional years of potential exposure, but at Naqada the frequencies do not differ among the adult age groups. Furthermore, the majority of the skeletal lesions observed in the Naqada skulls were remodelled, or healing. Skeletal lesions would begin to heal if the anemia subsided after childhood, although if anemia were to reoccur or were to continue into adulthood then the rate of healing may be slowed, leaving identifiable lesions in adult skeletal remains. Slower rates of healing due to anemia associated with multiple pregnancies appear to explain the high rates of porotic hyperostosis observed in middle adults from Naqada. Anemia would be less observable in middle adult males because more of their skeletal lesions would have healed completely in the absence of prolonged or episodic iron deficiency.

The anemia differences between the low and high status middle adult females suggest that the higher status females were more capable of adapting to the additional stresses of pregnancy than were the lower status females. The low status women likely had an even greater potential for developing anemia due to inferior hygiene, less nutritious diets, or the higher possibility of infection.

CONCLUSIONS

The disease frequencies observed in the Naqada skulls tend to support previous archaeological interpretations of social stratification, demonstrating the usefulness of skeletal analysis in the interpretation of complex societies. Although no variations attributable to status were detected in the frequencies of biparietal thinning, localized infection, or arthritis, statistically significant differences were found in the prevalence of anemia between the low and high status middle adult females. Middle adult females may have been especially susceptible to anemia because of the added demands for iron required by multiparity. Higher status women were perhaps more capable of adapting to the extra stress induced by pregnancies than were lower status women, due to better nutrition and overall health.

Table 4-1. Calculated and published frequencies of TMJ arthritis.

Population	% TMJ (n) arthritis	References
Naqada - Cemetery T	32.4 (34)	this study
Naqada - Great and B Cemeteries	33.0 (94)	this study
Medieval Nubians	13.9 (122)	Sheridan et al., 1991
Canadian Inuit Males	10.0 (33)	Merbs, 1983
Canadian Inuit Females	25.0 (39)	Merbs, 1983
Neolithic English	9.0 (22)	Hodges, 1991
Iron Age British	14.8 (41)	Hodges, 1991
Romano-British	23.3 (53)	Hodges, 1991
Anglo-Saxon	37.8 (159)	Hodges, 1991
Medieval British	30.3 (62)	Hodges, 1991
18th Century Londoners	32.0 (93)	Whittaker et al., 1990
Early Australian Aborigines	39.6 (101)	Richards and Brown, 1981

Table 4-2. Sex comparisons of porotic hyperostosis of the orbits (cemetery and age controlled).

Cemetery and Age	Females		Males		p-value
	#/n	%	#/n	%	
Cemetery BG					
Young Adults	3/6	50.0	2/6	33.3	1.00
Middle Adults	3/5	60.0	4/21	19.1	0.10*
Old Adults	5/11	45.5	11/21	52.4	1.00
Cemetery T					
Young Adults	-		-		-
Middle Adults	3/6	50.0	1/5	20.0	0.55
Old Adults	2/5	40.0	5/11	45.5	1.00

NOTE: 'BG'= Cemetery B and the Great Cemetery; '#'= number of affected individuals; 'n'= total subsample of individuals; '*'= statistically significant by the Fisher's Exact Test.

Table 4-3. Cemetery comparisons of porotic hyperostosis of the vault (age and sex controlled).

Sex and Age	Cemetery BG		Cemetery T		p-value
	#/n	%	#/n	%	
Females					
Young Adults	2/6	33.3	-	-	-
Middle Adults	4/5	80.0	1/7	14.3	0.07*
Old Adults	5/11	45.5	2/5	40.0	1.00
Males					
Young Adults	4/7	57.1	-	-	-
Middle Adults	10/21	47.6	2/5	40.0	1.00
Old Adults	11/24	45.8	2/11	18.2	0.15

NOTE: 'BG'= Cemetery B and the Great Cemetery; '#'= number of affected individuals; 'n'= total subsample of individuals; '*'= statistically significant by the Fisher's Exact Test.

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CHAPTER 5:
TEMPOROMANDIBULAR JOINT ARTHRITIS AT PREDYNASTIC NAQADA, EGYPT

INTRODUCTION

Osteoarthritis, a noninflammatory disorder characterized by the destruction of the articular cartilage and the proliferation and resorption of bone (de Bont et al., 1985a; Carlsson et al., 1979; Gold et al., 1988; Hutton, 1989; de Leeuw et al., 1993; McNeill, 1993; Sokoloff, 1980; Stegenga et al., 1991), is the most common pathological condition of the temporomandibular joint (TMJ) (Bates et al., 1993). Although TMJ arthritis has received considerable attention in recent medical literature due to its current widespread occurrence (e.g., Altman, 1987; Bates et al., 1993; Blaustein and Heffez, 1990; de Bont et al, 1985a; de Bont et al., 1985b; Dibbets and van der Weele, 1992a, 1992b; Gold et al., 1988; Hutton, 1989; Iacopino and Wathen, 1993; de Leeuw et al., 1993 McNeill, 1993; Ogus, 1987; Ogus and Toller, 1986; Parker, 1990; Seward, 1976; Stegenga et al., 1991), the condition also has been observed frequently in past populations (Jurmain, 1977). Skeletal evidence of TMJ arthritis has been reported in Predynastic and Dynastic Egyptians (Leek, 1972a), Mesolithic (Greene, 1972) and Medieval Nubians (Sheridan et al., 1991), Swedes from the Viking (Bergman and Hansson, 1979) and Middle Ages (Wedel et al., 1978), various British samples (Hodges, 1991; Whittaker et al., 1985; Whittaker et al., 1990), Canadian Inuit (Merbs, 1983), contemporary North Americans (Eversole et al., 1985), and Australian aborigines (Richards, 1988; Richards and Brown, 1981; Seward, 1976). Despite its frequent occurrence and long history however, the causes of temporomandibular joint arthritis are not completely understood (Bates et al., 1993; de Bont et al., 1985b; Carlsson et al., 1979; Iacopino and Wathen, 1993; McNeill, 1993; Ogus, 1987; Parker, 1990; Stegenga et al., 1991).

A precise etiology for TMJ arthritis is difficult to obtain, because the anatomy of the normal temporomandibular joint is very complex (Bates et al., 1993; Hutton, 1989; Ogus, 1987; Ogus and Toller, 1986; Stegenga et al., 1991). The TMJ is the unique bilateral diarthrodial joint formed between the cranium and the mandible. More specifically, the mandibular fossae and articular eminences of the temporal bone articulate with the condyles of the mandible (Alexanderson, 1967; Angel, 1948; Bates et al., 1993; Bauer, 1941; de Bont et al., 1985; McNeill, 1993; Moffett et al., 1964; Ogus and Toller, 1986). The TMJ is considered as one of the most elaborate articulations in the human body (McNeill, 1993) because it is a combination hinge (ginglymus) and sliding (arthrodial) joint, classified as a ginglymoarthrodial joint (Blaustein and Heffez, 1990;

McNeill, 1993). In addition, unlike most other synovial joints, the temporomandibular articulation contains fibrocartilage instead of hyaline cartilage (Bates et al., 1993; Blaustein and Heffez, 1990; de Bont et al., 1985; McNeill, 1993; Ogus and Toller, 1986). The two types of cartilage have similar functions, but differ in their compositions and reparative abilities. The proportion of water, for example, is approximately fifty percent in fibrocartilage compared to eighty percent in hyaline cartilage (Bates et al., 1993), and fibrocartilage is better able to repair itself (McNeill, 1993). Despite its unique features, the temporomandibular joint also contains characteristics of a typical diarthrodial joint, including a fibrous joint capsule, connective ligaments, and synovial fluid lubrication (McNeill, 1993). The TMJ, as a result, generally functions and responds to strains and stresses like other moveable joints (de Bont et al., 1985b). The complexity of the TMJ, however, is further complicated by its intricate relationship with the dentition (Bates et al., 1993; Hutton, 1989; Ogus, 1987; Ogus and Toller, 1986; Stegenga et al., 1991). Malocclusion, antemortem tooth loss, and dental wear, for example, are sometimes associated with TMJ arthritis (Bates et al., 1993; de Bont et al., 1985b; Carlsson et al., 1979; Costen, 1934; Dijkstra et al., 1993; Iacopino and Wathen, 1993; McNeill, 1993; Motegi et al., 1992; Ogus, 1987; Parker, 1990; Pullinger and Seligman, 1993; Pullinger et al., 1993; Toller, 1973). Given the complexities of the joint and its relationship with the teeth, a single cause of osteoarthritis is not very likely, and, as a result, multifactorial etiologies are often suggested (Bates et al., 1993; de Bont et al., 1985b; Dijkstra et al., 1993; Iacopino and Wathen, 1993; Jurmain, 1977; Ogus, 1987; Ogus and Toller, 1986; Parker, 1990; Stegenga, 1991).

In order to understand the multifactorial causes of TMJ arthritis better, it is advantageous to study evidence of temporomandibular joint arthritis in skeletal remains derived from autopsies or from archaeological excavations, because the joint surfaces are directly observable and not obscured by soft tissues (Jurmain, 1977). Clinical diagnoses of TMJ arthritis must rely on symptoms, which may include clicking, popping, and crepitation sounds, and jaw locking (Dibbets and van der Weele, 1992a; McNeill, 1993; Ogus, 1987; Ogus and Toller, 1986; Stegenga et al., 1991), supplemented by radiographs. The use of symptoms is problematic, because individuals with osteoarthritis are sometimes asymptomatic (Carlsson et al., 1979; Reiskin, 1979). Temporomandibular joint disorders do not always result in pain, because the cartilage and subchondral bone do not contain a nerve supply. Pain associated with TMJ arthritis instead results from the irritation of the innervated joint capsule and not directly from the joint surfaces (Bates et al., 1993; Carlsson et al., 1979; Ogus and Toller, 1986). Although radiographs may reveal the resorptive and proliferative lesions indicative of osteoarthritis (Bean et al., 1977), normal remodelling and pathological changes may be difficult to differentiate. The temporomandibular joint undergoes continuous remodelling in response to the changing stresses placed upon it (Angel, 1948; Blackwood, 1963; de Bont et al., 1985a; Moffett et al., 1964; Mongini, 1975; Ogus, 1987; Ogus and Toller, 1986; Parker, 1990; Tuominen et al., 1993). Remodelling attempts to maintain an equilibrium between joint form and function (Bates et al., 1993; Blackwood, 1963; de Bont et al., 1985; McNeill, 1993; Parker, 1990), but similar processes cause arthritic lesions.

This paper outlines the patterns of temporomandibular joint arthritis in the skulls of the Predynastic Upper Egyptians from the site of Naqada. The specific causes of TMJ arthritis in early ancient Egypt will be assessed in relation to the possibly contributing factors of antemortem tooth loss, dental wear, sex, and age. It was also impossible to ignore the indirect effects that social status may have had upon the frequencies of TMJ arthritis. Social stratification was previously interpreted for the site of Naqada through evaluations of the grave goods and grave sizes (Bard, 1989; Baumgartel, 1970; Castillos 1981, 1982, 1983; Davis, 1983; Petrie and Quibell, 1896). It was found that the low status individuals were interred in Cemetery B (located near the mound of Kom Belal) and the Great Cemetery (or the 'Great New Race Cemetery'), while the high status individuals were buried in Cemetery T (located near two tumuli) (Arkell and Ucko, 1975; Bard, 1992; Case and Payne, 1962; Kemp, 1973). Although Leek (1972a) previously reported TMJ arthritis frequencies for Egyptian materials, his study was not limited to the incipient stages of the ancient Egyptian civilization and the only causative factor he considered was dental wear. Egypt is a unique setting in which to test for the causes of TMJ arthritis because of the excellent preservation of the skeletal remains (Armelagos et al., 1980; Butzer, 1976; Hassan, 1988; Wenke, 1990).

MATERIALS AND METHODS

The site of Naqada was excavated in 1894-1895 under the direction of Sir William Matthew Flinders Petrie (Petrie and Quibell, 1896). Petrie recovered approximately 1900 graves from the Great Cemetery, 130 graves from Cemetery B, and an additional 58 graves from Cemetery T (Baumgartel, 1970). Although the majority of the tombs had been plundered in antiquity, Petrie used meticulous excavation techniques to derive as much information as possible (Baumgartel, 1970). In addition, unlike most other early Egyptian archaeologists, Petrie did not discard the skeletal remains he uncovered (Bard, 1992; Hoffman, 1979; Wenke, 1990). He retained approximately 400 skeletons that he subsequently sent to England for metric analyses (Fawcett and Lee, 1901-1902). The skulls were measured by Karl Pearson (1896), Herbert Thompson (for Petrie and Quibell, 1896), and Cicely Fawcett and Alice Lee (1901-1902), while the postcranial remains were analyzed by Ernest Warren (1897). The skeletal material was originally stored at University College, London, but is now located at Cambridge University where it forms part of the Duckworth Collection.

The present study sample consists of 132 crania derived from Cemetery B (n=34), Cemetery T (n=36), and the Great Cemetery (n=62). The postcranial remains are excluded from this study, because they were commingled following excavation. It is therefore impossible in some cases (Warren, 1897) and impractical in all cases to piece the skeletons back together. The majority of the skulls are partially (50-90% present) to completely preserved (90-100% present), and some of the material is fragmentary. Although the sex of each skeleton was previously estimated by G.D. Thane and Ernest Warren (Petrie and Quibell, 1896; Warren 1897), the skulls were re-assessed using more recent morphological techniques (Bass, 1987; Ubelaker, 1989; White, 1991). Age at death was also approximated for each skull. Age estimates were primarily based on the ectocranial suture closure method (Meindl and Lovejoy, 1985), although degree of dental wear (after Lovejoy, 1985) was used as a seriation aging technique for those skulls in which the sutures were not preserved. On the basis of these estimates, the Naqada individuals were classified into 'Young Adults' (21-30 years), 'Middle Adults' (31-40 years), and 'Old Adults' (41 years and older). Subadults were excluded, since dental eruption and growth may be complicating factors in temporomandibular joint remodelling (Carlsson et al., 1979; Dibbets and van der Weele, 1992b; Sheridan et al., 1991; Wedel et al., 1978). When precise sex or adult age at death estimates could not be determined, such as in the case of very fragmentary remains, the skulls were simply classified as 'Unknowns'.

Osteoarthritis of the temporomandibular joint was identified in the Naqada skulls by standard macroscopic methods outlined by Mann and Murphy (1990), Ortner and Putschar (1985), and Steinbock (1976) (e.g. Plate 5-1). Individuals were considered as affected by TMJ arthritis if they revealed characteristic surface changes in at least one articular fossa or condyle. Changes indicative of TMJ arthritis may include osteophytes, anterior lipping, sclerosis, erosions, and cortical cysts (Altman, 1987; Bates et al., 1993; Bean et al., 1977; Carlsson et al., 1979; Gold et al., 1988; Iacopino and Wathen, 1993; de Leeuw et al., 1993; McNeill, 1993; Ogus and Toller, 1986; Sokoloff, 1980; Stegenga et al., 1991).

The skulls were also examined for evidence of antemortem tooth loss and dental wear. For each individual, an antemortem tooth loss frequency was calculated by dividing the number of teeth lost prior to death by the total number of teeth still present plus the number of teeth lost antemortem. The degree of tooth wear was scored using a modified version of Smith's (1984) dental wear procedures. In order to maintain adequate subsample sizes, the eight stages of wear were collapsed into four: none, slight, moderate, and severe wear. Average tooth wear scores were subsequently calculated per Naqada individual.

Three statistical tests were used to identify intra- and inter-cemetery patterns: the chi-square test, the chi-square test with Yate's correction for continuity, and the Fisher's exact probability test. Although the standard chi-square test is normally adequate for detecting significant differences among categorical data (Blalock, 1979; Siegal and Castellan, 1988), limited sample sizes required the use of alternative methods. All three tests produce comparable probability values, but the chi-square test could only be used for large subsample comparisons. The corrected chi-square test was employed for small subsample comparisons or when at least one expected value fell below ten (after Blalock, 1979; Thomas, 1986). The Fisher's Exact test, on the other hand, was used for very small subsample analyses or when at least one expected value fell below five (after Blalock, 1979; Thomas, 1986). Because Cemetery B and Cemetery T were represented by a small number of graves (Baumgartel, 1970; Petrie and Quibell, 1896), small sample sizes were unavoidable. The subsample sizes were lowered further since it was necessary to control for the possible effects of sex and age at death.

The Fisher's Exact test is a powerful method for comparing very small subsample sizes, but it is only applicable to 2x2 contingency tables (Blalock, 1979). Because Naqada is represented by three cemeteries, it was necessary to pool the Cemetery B and Great Cemetery frequencies of TMJ arthritis. This was possible because the two cemeteries are archaeologically (Baumgartel, 1970) and genetically (Johnson and Lovell, 1994) similar. To maintain consistency, the B and Great Cemetery frequencies were combined for all comparisons regardless of the statistical method used.

The possible associations of antemortem tooth loss and dental wear with temporomandibular joint arthritis were considered. The association between these dental factors, normally scored per tooth, and TMJ arthritis, normally scored per individual, required the use of a fourth statistical test, the unpaired Student's t-test. For each individual, an average antemortem tooth loss score and an average wear score were calculated from the tooth scores. The t-test was subsequently utilized to compare average dental scores between healthy individuals and individuals affected by TMJ arthritis.

Following the analysis of the dental factors, the relationship of health and social status was evaluated by comparing disease frequencies between the cemeteries. The variables of sex and age were controlled to minimize their influence upon the results and to avoid Simpson's Paradox. Simpson's Paradox refers to the inaccurate results that are possibly obtained when the effects of variables extraneous to the primary comparison are ignored (Fingleton, 1984; O'Brien, 1989; Simpson, 1951; Upton, 1986). Multivariate statistical techniques avoid this possibility (Freeman, 1987; O'Brien, 1989; Upton, 1986), but the Naqada samples sizes were too small for such analyses. Alternatively, the extraneous variables were simultaneously controlled (after Blalock, 1979) by holding each at a constant value while testing for relationships among the primary variables. This process was repeated for every possible expression of the accessory variables. The Naqada osteoarthritis frequencies, for example, were compared between the cemeteries for each sex and age combination, such as young adult females, young adult males, middle adult females, and so on.

Furthermore, statistical tests were utilized to determine if sex or age at death had a significant effect upon the prevalence of osteoarthritis within the Naqada cemeteries. Because the demographic profiles differed within and between the cemeteries, it was necessary to control sex while examining the differences due to age, and alternatively to control age while testing for variations between the sexes.

RESULTS AND DISCUSSION

The sex, age, and cemetery distribution of Naqada individuals affected by temporomandibular osteoarthritis is presented in Table 5-1. The overall prevalence of TMJ arthritis for the total sample of Naqada individuals (n=128), including those of unknown sex and age, is 32.8%.

DENTAL FACTORS

Initial interest in the association of the dentition with temporomandibular joint arthritis was aroused by Costen (1934), who first suggested that malocclusion is possibly related to craniofacial disorders (McNeill, 1993; Ogus and Toller, 1986; Okeson et al., 1992). Following this classic study, the role of the dentition in the development of TMJ has often been assessed. Most researchers believe that the dental characteristics are related to TMJ arthritis to some extent, but that they are not the only contributing factors (Bates et al., 1993; de Bont et al., 1985b; Carlsson et al., 1979; Dijkstra et al., 1993; Iacopino and Wathen, 1993; McNeill, 1993; Motegi et al., 1992; Ogus, 1987; Parker, 1990; Pullinger and Seligman, 1993; Pullinger et al., 1993;

Toller, 1973). Dental malocclusion, for example, is sometimes suggested as an initiating or predisposing factor in TMJ arthritis (Bates et al., 1993; Ogus, 1987; Parker, 1990). Malocclusion caused by crowding, open bite, and extensive overjet, for example, has been associated with the condition (Motegi et al., 1992). The exact relationship between malocclusion and TMJ arthritis, however, has yet to be determined. Individuals affected with TMJ osteoarthritis often have normal occlusion (Motegi et al., 1992) and in some studies malocclusion has been ruled out by controlling age (Whittaker et al., 1990). Occlusal status was not assessed for each of the Naqada skulls, because the majority of the dentitions were incomplete.

In addition to malocclusion, antemortem tooth loss is sometimes correlated with osteoarthritis (Bergman and Hanssen, 1979; Carlsson et al., 1979; Merbs, 1983; Öberg et al., 1971; Richards and Brown, 1981; Whittaker et al., 1985). Loss of molar support may result in an unstable joint in which the mandibular condyles have a greater range of motion. As a result, stresses may be increased and exerted upon non-load bearing areas of the temporomandibular joint (Carlsson et al., 1979). However, joints that are genetically hypermobile do not necessarily exhibit higher frequencies of osteoarthritis (Dijkstra et al., 1993). In addition, other researchers have failed to find an association between tooth loss and arthritic changes (Hodges, 1991; de Leeuw et al., 1993; Wedel et al., 1978; Whittaker et al., 1990). Hodges (1991) suggests that studies reporting an association between tooth loss and osteoarthritis may have overlooked the effects of age. A correlation between antemortem tooth loss and arthritis in a series of Romano-British skeletons disappeared when age at death was simultaneously considered (Hodges, 1991).

The stability of the temporomandibular joint is also affected by dental wear. Posterior wear, for example, may cause uneven loads and abnormal stresses in the temporomandibular joint (Iacopino and Wathen, 1993). Some studies have found that wear is associated with TMJ arthritis (Pullinger and Seligman, 1993), although wear is not likely a primary cause (Pullinger and Seligman, 1993; Pullinger et al., 1993). Wear due to parafunctional activities such as bruxism, clenching, and abnormal postures may also contribute to the development of TMJ arthritis (Iacopino and Wathen, 1993; McNeill, 1993; Motegi et al., 1992; Ogus, 1987; Parker, 1990). The exact role of abnormal wear is uncertain (Pullinger and Seligman, 1993), however, since bruxists do not always have higher frequencies of arthritic changes in their temporomandibular joints (Seligman et al., 1988; Stegenga et al., 1991).

In general, antemortem tooth loss and severe dental wear were not found to be associated with temporomandibular joint arthritis in the Naqada skulls (Tables 5-3 and 5-4).

Given the severe degrees of tooth wear observed, however, it seems unlikely that the dentition had no effect upon TMJ arthritis frequencies at Naqada. Statistically significant differences may have been undetectable because of small sample sizes. Despite the lack of statistical association, TMJ arthritis and dental wear may be related nonetheless. A weak association may only be detectable through the simultaneous examination of numerous variables utilizing multivariate methods. It was impossible to analyze the etiology of TMJ arthritis at Naqada with the use of multivariate statistics, however, because of small subsample sizes. The use of the chi-square, corrected chi-square, and Fisher's Exact test did allow for the simultaneous control of variables extraneous to primary comparisons, but precise multivariate interactions could not be evaluated.

Although psychological causes of dental wear cannot be ruled out, wear in the Naqada skulls is more likely related to the diet and to the presence of grit in the food of the Egyptians. The typical ancient Egyptian diet likely consisted of bread, vegetables, fruit, and fish, and occasionally meat (Hillson, 1979; Saffirio, 1972; Wilson, 1988). Plant foods, which are more abrasive than meat, would have contributed to dental wear to some extent (Hillson, 1979). In addition, sand from the surrounding desert and also from the stone grinding of grain was common in the bread (Leek, 1972b; Wilson, 1988), the main dietary staple (Wilson, 1988).

When compared to other Nile Valley samples (Table 5-2), the Naqada frequencies of TMJ arthritis are comparable to those calculated for a diverse sample of Egyptian skulls that spanned several thousand years in the Predynastic and Dynastic periods (Lekk, 1972a), but are much higher than those presented for Medieval (ca. 550-1500 A.D.) Nubians (Sheridan et al., 1991). These variations may be attributed to the different cultural periods represented, since the Naqada frequencies are comparable to those of earlier Mesolithic Nubians (Greene, 1972), who had similar subsistence practices. The Predynastic Egyptians fished and hunted as they had during the Mesolithic and they augmented these activities with small-scale plant cultivation (Saffirio, 1972). Dynastic Egyptians and Medieval Nubians, in contrast, were fully agricultural and had less tooth wear. As is clear from Table 5-2, there is considerable variation in TMJ arthritis frequencies, undoubtedly due to cultural differences. Australian aborigines, for example, generally reveal high frequencies of TMJ arthritis that are thought to be associated with high degrees of tooth wear (Richards, 1990). Differences among the aborigines may also reflect variations in subsistence practices. Narrinyeri fishermen, for example, revealed lower tooth wear scores and TMJ arthritis frequencies than did Kaurna hunter-gatherers (Richards, 1990). In comparison to Australian aborigines, modern American males exhibit minimal dental wear and subsequently lower frequencies of TMJ arthritis (Eversole et al., 1985). Significant associations between dental wear and TMJ arthritis were also found in a study of five British skeletal samples (Hodges, 1991).

SOCIAL STATUS

Social stratification may indirectly influence the frequency of TMJ arthritis, since social status often has an effect upon lifestyle. When comparing individuals within a stratified society, therefore, different frequencies of TMJ arthritis may be expected. Social position, for example, may affect one's exposure to pathogens and injuries. Lower status individuals are more likely to suffer from conditions associated with inadequate sanitation, poor hygiene, heavy work loads, and malnutrition than are higher status individuals. The likelihood of developing TMJ arthritis is probably related to the quality of the diet consumed. For example, grit in the diet from the surrounding desert and from the stone grinding of grain may be responsible for the extreme examples of dental wear observed in the ancient Egyptian teeth (Leek, 1972b; Wilson, 1988). Grit was likely unavoidable in bread, although better quality loaves were probably of a finer texture. Lower status Egyptians are thought to have consumed more rough-textured barley bread than fine-textured emmer bread (Wilson, 1988). The possible relationship between status, as represented by the low and high status Naqada cemeteries, and TMJ arthritis was therefore considered.

Cemetery comparisons of the frequencies of osteoarthritis did not reveal any statistically significant differences, however, when the sample was differentiated by sex and age (Table 5-5). This does not negate the possibility of social status differences between the cemeteries, but does suggest that the ancient Egyptians were similarly exposed to the causative factors of TMJ arthritis regardless of their social status. Therefore, when considering the prevalence of TMJ arthritis, it appears that social stratification during the Predynastic period had not yet affected this aspect of the health of the ancient Egyptians. This is not unexpected because differences in social status were much less pronounced at this time than they were during the Dynastic age. For example, status was represented by grave offerings in the Predynastic, which is unlike the grandiose architectural displays of wealth and power during Dynastic times. Despite the similarities in the frequencies of TMJ arthritis between the status groups at Naqada, the cemeteries could not be combined for subsequent analyses because the prevalence of antemortem tooth loss and the severity of dental wear differed significantly between the cemeteries (Table 5-6 and 5-7), and, as was indicated previously, such dental factors are likely related to TMJ arthritis frequencies. As a result, subsequent investigations into the causes of TMJ arthritis at Naqada were conducted for each cemetery separately.

SEX

Although the female and male young adults could not be compared because of missing values, no statistically significant differences were found when the frequencies of arthritis in the Naqada skulls were compared between the sexes with age and cemetery controlled (Table 5-8). Many other studies have reported, however, that females are more susceptible to TMJ arthritis than are males (Bates et al., 1993; Dibbets and van der Weele, 1992a; Gold et al., 1988; Merbs, 1983; Ogus and Toller, 1986; Parker, 1990; Sheridan et al., 1991; Toller, 1973). For example, in a clinical study of 130 patients, affected females outnumbered males by a ratio of six to one (Toller, 1973). Similarly, a skeletal study of the Sadlermiut Inuit revealed that affected females outnumbered males two and one half to one (Merbs, 1983).

Habitual activities, variations in joint structure and anatomy, hormones, and sensitivities to pain have all been suggested as causes of sex differences in TMJ arthritis. The frequencies of TMJ arthritis observed among male and female Sadlermiut Inuit, for example, may be explained by habitual actions related to gender roles. The female Sadlermiut are responsible for the softening of skins with their teeth, and, as a result, have much higher frequencies of TMJ arthritis when compared to the male Sadlermiut (Merbs, 1983). Anatomical differences between females and males may also contribute to variations in degenerative changes. Females may be predisposed to arthritis because they tend to have retropositioned mandibular condyles (Pullinger, 1987). In addition, males often have stronger muscles and ligaments that may better support the temporomandibular joint and absorb stresses more effectively (Seligman et al., 1988). Aside from anatomical differences, increased frequencies in late middle-aged females have sometimes been attributed to changing hormone levels (Jurmain, 1977). Furthermore, females may be more highly sensitive to pain (Feine et al., 1989), which may affect the subjective reporting of the condition (Motegi et al., 1992). As a result, TMJ arthritis frequencies based on reported symptoms may not accurately reflect actual arthritis frequencies, since females may be overrepresented in clinical studies simply because they report the symptoms more often. Dibbets and van der Weele (1992) found significant differences between female and male 19 year olds who subjectively reported jaw clicking. The differences were not significant, however, when the same individuals were objectively palpated for clicking. Motegi and others (1992) found no sex differences in examining over 7000 Japanese children.

The similar frequencies of TMJ arthritis between the sexes at Naqada are consistent with the objective findings of such clinical studies. Other skeletal studies have also found similar frequencies of TMJ osteoarthritis between females and males (Hodges, 1991; Richards and Brown, 1981; Whittaker et al., 1985; Whittaker et al., 1990). Hodges (1991), for example, found no differences attributable to sex in her study of ancient English skulls that ranged from Neolithic times to the 18th Century, and she therefore concludes that sex is not a predisposing factor of TMJ arthritis.

AGE

Very small subsample sizes prevented a formal statistical evaluation of the effects of age upon the frequency of TMJ arthritis. The percentage of osteoarthritis tended to increase with age, however, within the low and high status cemeteries and for both sexes. This trend is consistent with both clinical and skeletal studies that commonly report an increasing prevalence of TMJ arthritis with age (Altman, 1987; Bates et al., 1993; Blackwood, 1963; de Bont et al., 1985b; Carlsson et al., 1979; Dibbets and van der Weele, 1992a; Gold et al., 1988; Hodges, 1991; Iacopino and Wathen, 1993; Moffett et al., 1964; Öberg et al., 1971; Richards, 1988, 1990; Richards and Brown, 1981; Sheridan et al., 1991; Wedel et al., 1978). Although aging is not considered as a primary cause of TMJ arthritis, it is a predisposing factor (Carlsson et al., 1979; de Bont et al., 1985b; Iacopino and Wathen, 1993; Jurmain, 1977; McNeill, 1993). In general, the cause of osteoarthritis is thought to be related to the repetitive overloading of the joint (Bates et al., 1993; de Bont et al., 1985a; Carlsson et al., 1979; Dijkstra et al., 1993; Iacopino and Wathen, 1993; McNeill, 1993; Ogus, 1987; Ogus and Toller, 1986). Arthritis may result when habitual overload eventually exceeds the joint's adaptive capacity (Bates et al., 1993; Bauer, 1941; de Bont et al., 1985a; de Bont et al., 1985b; Carlsson et al., 1979; Dijkstra et al., 1993; Gold et al., 1988; Iacopino and Wathen, 1993; Moffett et al., 1964; Ogus, 1987; Parker, 1990; Sokoloff, 1980; Stegenga et al., 1991). This capacity is apparently reduced in older individuals (de Bont et al., 1985a; Iacopino and Wathen, 1993). With age, the joint breaks down so that normal joint loads, which are required for the proper development and function of the joint (Iacopino and Wathen, 1994), become too great for the joint tissues to sustain them (Altman, 1987; Bates et al., 1993; Hutton, 1989; Ogus, 1987; Ogus and Toller, 1986; Stegenga et al., 1991).

It is commonly agreed that TMJ arthritis begins in the fibrocartilaginous disc, since cartilage is prone to fatigue and cannot repair itself as readily as bone (Carlsson et al., 1979; Gold et al., 1988; Iacopino and Wathen, 1993; de

Leeuw et al., 1993; Moskowitz, 1977; Ogus and Toller, 1986). The articular disc is comprised of chondrocytes within a proteoglycan and collagen fibril matrix (McNeill, 1993; Moskowitz, 1977). Overload can eventually cause the disintegration of the collagen network. The cartilage subsequently swells (Bates et al., 1993; Bean et al., 1977; Carlsson et al., 1979), because the osmotic pressure is no longer contained by the damaged fibres (de Bont et al., 1985a). This allows for the release of the proteoglycans into the joint cavity, resulting in fibrillation in which the normal firm cartilage becomes soft, uneven, and fissured (de Bont et al., 1985a; Iacopino and Wathen, 1993; Moffett et al., 1964). In addition, deterioration and the eventual perforation of the disc may result (Bean et al., 1977; Carlsson et al., 1979; Ogus and Toller, 1986). In older individuals, arthritic changes are presumably associated with the decrease in the fibrous and proteoglycan composition of the cartilage that occurs with age (de Bont et al., 1985b; Iacopino and Wathen, 1993). Furthermore, elastic fibers, unique to fibrocartilaginous joints, likely lose tensile fatigue strength with age (de Bont et al., 1985b). In addition to articular cartilage changes, the chance of joint overload occurring increases with time (Jurmain, 1977). Although degenerative changes increase with age, TMJ arthritis is not uncommon in younger individuals (Bates et al., 1993; de Bont et al., 1985b; Jurmain, 1977; Ogus and Toller, 1986). Not only can arthritis result from normal loads in older joints, but the condition can also be caused by excessive stresses in healthy younger joints. Such excessive stresses have been associated with factors such as antemortem tooth loss and severe dental wear (Bates et al., 1993; de Bont et al., 1985b; Carlsson et al., 1979; Dijkstra et al., 1993; Iacopino and Wathen, 1993; McNeill, 1993; Motegi et al., 1992; Ogus, 1987; Parker, 1990; Pullinger and Seligman, 1993; Pullinger et al., 1993; Toller, 1973).

Studies restricted to skeletal evidence of TMJ arthritis clearly benefit from the soft tissue information that clinical analyses provide, such as those that have identified changes due to aging. It is difficult, however, to compare arthritis frequencies between skeletal and clinical studies, because skeletal frequencies may be underrepresented. Bony changes associated with TMJ osteoarthritis are thought to occur in the later stages of the condition (McNeill, 1993).

CONCLUSIONS

The results of this study illustrate several important patterns in the prevalence of TMJ arthritis specific to Predynastic Egypt. First, the overall percentage of individuals affected by TMJ arthritis at Naqada was 32.8%, which is similar to frequencies reported for comparable skeletal samples from Egypt and Nubia. Second, in contrast with clinical studies, which commonly report that females are more often affected by TMJ arthritis than are males, the frequencies of osteoarthritis in the Naqada skulls were similar between the sexes. The similarity is consistent with other skeletal studies that have also failed to find differences attributed to sex. Third, the prevalence of TMJ arthritis tended to increase with age, a trend which is commonly reported in both clinical and skeletal studies. Age, however, is not likely the only predisposing factor in the development of TMJ arthritis at Naqada, because degenerative changes were also observed in the younger adults. Fourth, although antemortem tooth loss and dental wear have been linked to TMJ arthritis in clinical assessments, neither condition was significantly associated with TMJ arthritis frequencies in this study. Problems associated with small sample sizes at Naqada may be alleviated in future analyses by augmenting the Naqada material with similar Predynastic skeletal samples.

Table 5-1. Sex, age, and cemetery distributions of temporomandibular joint arthritis at Naqada.

Sex and Age	Combined B and Great Cemeteries		Cemetery T		Total	
	#/n	%	#/n	%	#/n	%
Female						
Young Adult	0/7	0.0	0/1	0.0	0/8	0.0
Middle Adult	2/8	25.0	3/7	42.9	5/15	33.3
Old Adult	5/14	35.7	0/4	0.0	5/18	27.8
Adult	-	-	0/2	0.0	0/2	0.0
Male						
Young Adult	2/7	28.6	-	-	2/7	28.6
Middle Adult	8/25	32.0	2/6	33.3	10/31	32.3
Old Adult	10/26	38.5	4/11	36.4	14/37	37.8
Adult	2/2	100.0	2/3	66.7	4/5	80.0
Unknown						
Young Adult	-	-	-	-	-	-
Middle Adult	1/2	50.0	-	-	1/2	50.0
Old Adult	1/3	33.3	-	-	1/3	33.3
Adult	-	-	-	-	-	-
Total	31/94	33.0	11/34	32.4	42/128	32.8

Note: '#' = number of affected individuals in the subsample; 'n' = total number of individuals in the subsample; '%' = percentage of the subsample affected by TMJ arthritis; '-' = unobservable values.

Table 5-2. Published frequencies of temporomandibular joint arthritis in various skeletal samples.

Site - Time Period	% TMJ (n) arthritis	Reference
EGYPT		
-Naqada Cemetery T	32.4 (34)	this study
-Naqada Cemeteries B&G	33.0 (94)	this study
-various	39.2 (51)	Leek, 1972a
NUBIA		
-Mesolithic	38.9 (18)	Greene, 1972
-Kulubnarti - Medieval	13.9 (122)	Sheridan et al., 1991
NORTH AMERICA		
-Canadian Sadlermiut Inuit ♂	10.0 (33)	Merbs, 1983
-Canadian Sadlermiut Inuit ♀	25.0 (39)	Merbs, 1983
-Modern American ♂	23.1 (40)	Eversole et al., 1985
AUSTRALIA		
-Narrinyeri Aborigines	31.9 (74)	Richards, 1988
-Kaurna Aborigines	40.5 (38)	Richards, 1988
-various Aborigines	39.6 (101)	Richards and Brown, 1981

Note: 'n' = number of individuals.

Table 5-3. Comparisons of average antemortem tooth loss frequencies between healthy individuals and individuals affected by TMJ arthritis.

Cemetery Sex and Age	TMJ arthritis absent		TMJ arthritis present		P-value
	n	average AMTL %	n	average AMTL %	
Combined B and Great Cemeteries					
Females					
Young Adults	7	1.19	0	-	-
Middle Adults	6	8.03	2	33.35	0.59
Old Adults	9	15.06	5	13.78	0.93
Males					
Young Adults	5	4.34	2	4.55	-
Middle Adults	13	6.28	8	20.51	0.32
Old Adults	15	34.54	10	16.16	0.11
Cemetery T					
Females					
Young Adults	1	0.00	0	-	-
Middle Adults	2	12.50	2	0.00	-
Old Adults	2	0.00	0	-	-
Males					
Young Adults	0	-	0	-	-
Middle Adults	4	13.75	2	0.00	-
Old Adults	4	16.68	3	27.80	0.69

Note: 'n' = number of individuals; 'AMTL average %' = average percentage of antemortem tooth loss among the subsample individuals; '-' = antemortem tooth loss unobservable or t-test statistic not calculable.

Table 5-4. Comparisons of average tooth wear between healthy individuals and individuals affected by TMJ arthritis.

Cemetery Sex and Age	TMJ arthritis absent n	TMJ arthritis absent average wear %	TMJ arthritis present n	TMJ arthritis present average wear %	P-value
Combined B and Great Cemeteries					
Female					
Young Adult	7	1.10	0	-	-
Middle Adult	6	1.63	2	2.35	0.46
Old Adult	8	1.81	5	2.22	0.08
Male					
Young Adult	5	1.20	2	1.40	-
Middle Adult	13	1.61	7	1.86	0.22
Old Adult	13	2.30	10	2.09	0.52
Cemetery T					
Female					
Young Adult	1	1.00	0	-	-
Middle Adult	4	1.17	2	1.20	0.91
Old Adult	2	1.30	0	-	-
Male					
Young Adult	0	-	0	-	-
Middle Adult	4	1.73	2	1.45	0.58
Old Adult	2	1.35	3	2.07	0.28

Note: '#' = number of affected individuals in the subsample; 'n' = total number of individuals in the subsample; '%' = percentage of the subsample affected by TMJ arthritis; '-' = unobservable values.

Table 5-5. Comparisons of TMJ arthritis frequencies between the cemeteries with sex and age controlled.

Sex and Age	B and Great Cemeteries		Cemetery T		Test	P-value
	#/n	%	#/n	%		
Female						
Young Adult	0/7	0.0	0/1	0.0	-	
Middle Adult	2/8	25.0	3/7	42.9	Fisher's	0.61
Old Adult	5/14	35.7	0/4	0.0	Fisher's	0.28
Male						
Young Adult	2/7	28.6	-	-	-	
Middle Adult	8/25	32.0	2/6	33.3	Fisher's	1.00
Old Adult	10/26	38.5	4/11	36.4	Fisher's	1.00

Note: '#' = number of affected individuals in the subsample; 'n' = total number of individuals in the subsample; '%' = percentage of the subsample affected by TMJ arthritis; '-' = unobservable values.

Table 5-6. Comparisons of antemortem tooth loss frequencies between the cemeteries with sex and age controlled.

Sex and Age	BG		T		Test & P-value	
	#/n	%	#/n	%		
Females						
Young Adults	1/55	1.8	0/6	0.0	Fisher's	1.00
Middle Adults	10/79	12.7	2/30	6.7	Fisher's	0.51
Old Adults	21/132	15.9	0/8	0.0	Fisher's	0.61
Males						
Young Adults	4/84	4.8	-	-	-	
Middle Adults	28/249	11.2	11/60	18.3	Yate's	0.21
Old Adults	89/300	29.7	8/52	15.4	χ^2	0.03*

Note: '#' = number of teeth missing antemortem; 'n' = total number of teeth present in the subsample plus the number of teeth missing antemortem; '%' = percentage of the subsample affected; '-' = unobservable values; '*' = statistically signficant.

Table 5-7. Comparisons of the degrees of dental wear between the cemeteries with sex and age controlled.

Sex, Age, and Degree of Dental Wear	B and Great Cemeteries		Cemetery T		Test	P-value
	#/n	%	#/n	%		
Females						
Young Adults	# skulls=7		# skulls=1		Fisher's	0.57
slight	34/41	82.9	6/6	100		
moderate	7/41	17.1	0/6	0.0		
Middle Adults	# skulls=8		# skulls=7		χ^2	0.06*
slight	24/59	40.7	11/15	73.3		
moderate	27/59	45.8	4/15	26.7		
severe	8/59	13.6	0/15	0.0		
Old Adults	# skulls=14		# skulls=4		-	-
slight	26/79	32.9	2/3	66.7		
moderate	36/79	45.6	1/3	33.3		
severe	17/79	21.5	0/3	0.0		
Males						
Young Adults	# skulls=7		# skulls=0		-	-
slight	51/70	72.9	-	-		
moderate	19/70	27.1	-	-		
Middle Adults	# skulls=25		# skulls=6		χ^2	0.001*
slight	84/172	48.8	13/29	44.8		
moderate	77/172	44.8	8/29	27.6		
severe	11/172	6.4	8/29	27.6		
Old Adults	# skulls=26		# skulls=11		χ^2	0.006*
slight	43/175	24.6	17/34	50.0		
moderate	71/175	40.6	12/34	35.3		
severe	61/175	34.9	5/34	14.7		

Note: '#' = number of affected teeth; 'n' = total number of teeth in the subsample; '%' = percentage of the subsample affected; '-' = unobservable values; '*' = statistically signficant.

Table 5-8. Comparisons of TMJ arthritis frequencies between the sexes with cemetery and age controlled.

Cemetery and Age	Females		Males		Test & P-value
	#/n	%	#/n	%	
B & Great Cemeteries					
Young Adult	0/7	0.0	2/7	28.6	Fisher's 0.46
Middle Adult	2/8	25.0	8/25	32.0	Fisher's 1.00
Old Adult	5/14	35.7	10/26	38.5	Fisher's 1.00
Cemetery T					
Young Adult	0/1	0.0	-	-	-
Middle Adult	3/7	42.9	2/6	33.3	Fisher's 1.00
Old Adult	0/4	0.0	4/11	36.4	Fisher's 1.00

Note: '#' = number of affected individuals in the subsample; 'n' = total number of individuals in the subsample; '%' = percentage of the subsample affected by TMJ arthritis; '-' = unobservable values.

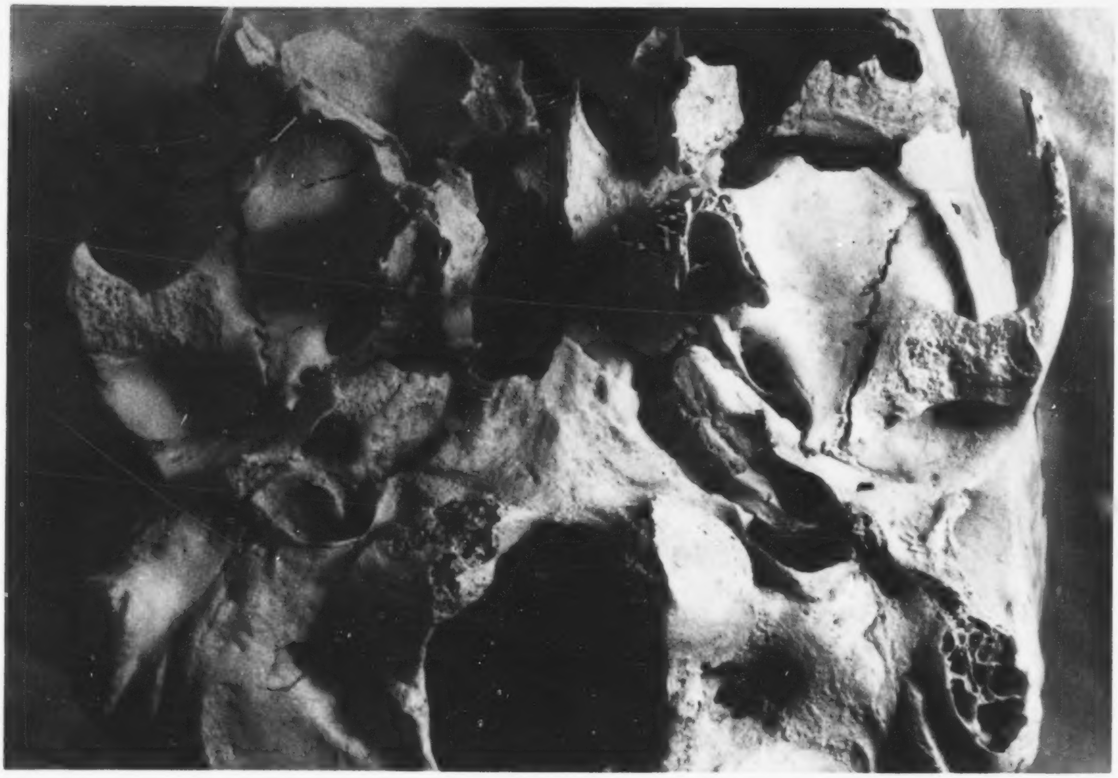

Plate 5-1. An example of temporomandibular joint arthritis (Female, 35-45 years, Cemetery T, Grave #14, Duckworth #Af.11.5.445).

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CHAPTER 6:
ASSOCIATIONS OF POROTIC HYPEROSTOSIS AND SOCIAL STATUS AT PREDYNASTIC NAQADA, EGYPT

INTRODUCTION

Anemia currently affects up to 30 percent of the world's population (Kent, 1992). Anemia may have been a similarly common health problem in antiquity, assuming that the skeletal lesions of porotic hyperostosis represent this blood disorder (Kent, 1992; Kent and Weinberg, 1989). Porotic hyperostosis is frequently reported in studies of past populations (e.g., Angel, 1966; El-Najjar et al., 1976; Lallo et al., 1977; Mensforth et al., 1978; Palkovich, 1987; Ortner and Putschar, 1985; Steinbock, 1976; Stuart-Macadam, 1987a, 1987b, 1989a; Walker, 1985, 1986), including ancient Egypt and Nubia (Carlson et al., 1974; Hillson, 1980; Leek, 1980; Lovell, in press; Mittler and Van Gerven, 1994; Vagn Nielsen, 1970; Van Gerven et al., 1981).

It is generally agreed that anemia is a deficiency of the circulating red blood cells resulting from a reduction in hemoglobin concentrations and/or hematocrit, the percentage of packed red blood cells per unit volume of blood (Garn, 1992; Kent, 1992; Pippard and Hoffbrand, 1989). The condition may be caused by genetic disorders, such as thalassemia and sickle cell anemia (Wainscoat, 1989), or by iron deficiencies acquired through blood loss, dietary deficits, inadequate iron absorption, excess hemolysis, or infection (Custer, 1974; Pippard and Hoffbrand, 1989; Stedman, 1982; Stuart-Macadam, 1992a, 1992b; Wadsworth, 1992).

The majority of iron can be found in the hemoglobin of circulating red blood cells (Arthur and Isbister, 1987; Pippard and Hoffbrand, 1989). The remaining iron is stored in the bone marrow, liver, and spleen as an emergency reserve source (Cook, 1990). Iron deficiency results when iron loss exceeds iron intake (Pippard and Hoffbrand, 1989). Although it is difficult to separate the causes of anemias from their effects (Kent, 1992), certain symptoms, such as pallor, breathlessness, and fatigue (Custer, 1974; Garn, 1992; Pippard and Hoffbrand, 1989), are apparent. Further, in infants and children, anemia may influence mental and physical development (Pippard and Hoffbrand, 1989), while in adults, anemia may impair work and exercise abilities (Custer, 1974; Pippard and Hoffbrand, 1989). Severe or prolonged anemia can eventually lead to widespread tissue changes, abnormal immunity, and cardiac and respiratory failure (Cook, 1990).

Although the precise cause of porotic hyperostosis has been debated, it is generally agreed that the skeletal lesions are indicative of acquired or genetic anemia (Angel, 1966; Carlson et al., 1974; El-Najjar et al., 1976; Hengen, 1971; Lallo et al., 1977; Mensforth et al., 1978). Anemia causes tissue hypoxia that stimulates hematopoietic bone marrow to increase its production of red blood cells (Pippard and Hoffbrand, 1989). The expansion of the bone marrow results in a thickened diploë or middle layer. As it expands outwards away from the brain, the marrow exerts pressure on the surrounding bone. The resulting pressure damages the compact bone of the outer table and results in the porous skeletal lesions (Caffey, 1937) referred to as porotic hyperostosis. The term porotic hyperostosis (after Angel, 1966), more specifically, describes the unique and often symmetrical pitting in the compact bone of the outer cranial vault and orbital roof that is associated with the thickened diploic layer (Armelagos, 1969; Carlson et al., 1974; Mann and Murphy, 1990; Mensforth et al., 1978; Steinbock, 1976; Stuart-Macadam, 1985, 1987a, 1987b). The pitting ranges from small pinpricks to large interconnecting apertures that can give a sponge-like appearance to the outer surface of the skull (Stuart-Macadam, 1989b). Cribra orbitalia specifically refers to porotic hyperostosis in the eye orbits (Nathan and Haas, 1966). In addition to the orbital roof, porotic hyperostosis may affect the frontal, occipital, and especially the parietal bones of the skull vault (Ortner and Putschar, 1985). Both orbital and vault lesions are thought to be caused by anemia, although they are not always associated with one another (Ortner and Putschar, 1985; Steinbock, 1976; Stuart-Macadam, 1989b).

Microscopically, porotic hyperostosis is represented by large marrow spaces and a thinned or absent outer table (Stuart-Macadam, 1987b). Seven radiographic criteria indicative of porotic hyperostosis were established by Stuart-Macadam (1987a) and include: 1) "hair-on-end" pattern of trabecular bone; 2) thinning or complete destruction of the outer table; 3) uneven, granular texture in bone that is normally unified; 4) thickening of the diploic layer; 5) thickening of the orbital roof; 6) orbital rim irregularities; and 7) inhibited frontal sinus development.

This paper outlines the patterns of cribra orbitalia and porotic hyperostosis of the vault in Predynastic Upper Egyptians from Naqada. In addition to evaluating the influences of sex and age upon anemia frequencies, the possible effects that social stratification had upon diet and sanitation, and ultimately upon the prevalence of porotic hyperostosis, will be considered, because Naqada is one of the earliest Egyptian sites to reveal social status differences (Bard, 1992; Baumgartel, 1970; Castillos, 1981, 1982, 1983; Davis, 1983; Hoffman, 1979). Social stratification was previously interpreted for the site of Naqada through evaluations of the grave goods and grave sizes (Bard, 1989; Baumgartel, 1970; Castillos 1981, 1982, 1983; Davis, 1983; Petrie and Quibell, 1896). It was found that the low status individuals were interred in Cemetery B and the Great Cemetery, while the high status individuals were buried in Cemetery T (Arkell and Ucko, 1975; Bard, 1992; Case and Payne, 1962; Kemp, 1973). Cemetery comparisons of porotic hyperostosis frequencies, therefore, provide a context in which to test for the indirect effects of social stratification. Predynastic Egypt is a unique setting for such an analysis, because of the direct evidence of social differences in the form of grave goods (Bard, 1989; Davis, 1983; Castillos, 1981, 1982, 1983), and the excellent preservation of the skeletal remains (Armelagos et al., 1980; Butzer, 1976; Hassan, 1988; Wenke, 1990).

MATERIALS AND METHODS

Naqada was excavated by Sir William Matthew Flinders Petrie in 1894-1895 (Petrie and Quibell, 1896). Petrie discovered over 2000 graves at Naqada: 1900 in the Great Cemetery, 130 in Cemetery B, and 58 in Cemetery T (Baumgartel, 1970). Unfortunately, the majority of the tombs had been plundered in antiquity, although Petrie was able to recover over 400 skeletons that he subsequently sent to England for metric analyses (e.g., Fawcett and Lee, 1901-1902; Pearson, 1896; Petrie and Quibell, 1896; Warren, 1897). The skeletal material, originally stored at University College, London, is now housed at Cambridge University as part of the Duckworth Collection.

The sample analyzed in this study includes 132 crania from Cemetery B (n=34), Cemetery T (n=36), and the Great Cemetery (n=62). The postcranial bones were not examined, because they were commingled following excavation. As a result, it is impossible in some cases (Warren, 1897) and impractical in all cases to rearticulate the skeletons. Although some of the Naqada skulls are fragmentary, the majority are partially (50-90% present) to completely preserved (90-100% present). The sex of each skeleton was originally estimated by G.D. Thane and Ernest Warren (Petrie and Quibell, 1896; Warren 1897), but the skulls were re-evaluated using contemporary methods and standards (Bass, 1987; Ubelaker, 1989; White, 1991). Age at death was also assessed for each skull and was based primarily on the ectocranial suture closure technique (after Meindl and Lovejoy, 1985). For the skulls without preserved sutures, degree of dental wear (after Lovejoy, 1985) was used as a seriation aging method. The Naqada individuals were subsequently classified into 'Young Adults' (21-30 years), 'Middle Adults' (31-40 years), and 'Old Adults' (41 years and older) based on these estimates. Subadults were excluded from this study because growth may be a complicating factor in the development of the pathological lesions. Adult skulls were classified as 'Unknowns' when sex or age at death could not be estimated, such as in the case of very fragmentary remains.

Porotic hyperostosis of the vault and orbits were identified in the Naqada skulls based on standard macroscopic methods outlined by Mann and Murphy (1990), Ortner and Putschar (1985), and Steinbock (1976) (e.g. Plate 6-1). Skulls that revealed characteristic changes in at least one area of the frontal, parietal, or occipital bones were considered to be affected by porotic hyperostosis. Similarly, crania exhibiting lesions in at least one orbital roof were categorized as affected by cribra orbitalia. Although they are sometimes related, porotic hyperostosis of the vaults and orbits were analyzed separately in this study, because preliminary tests failed to reveal a statistical association between them.

Three statistical tests were utilized to identify patterns of porotic hyperostosis within and between the cemeteries: the chi-square test, the chi-square test with Yate's correction for continuity, and the Fisher's exact probability test. All three tests produce comparable probability values. The standard chi-square test is normally useful for detecting statistically significant differences among categorical data (Blalock, 1979; Siegal and Castellan, 1988). However, small sample sizes from the limited numbers of graves in Cemetery B and T necessitated the use of alternative test statistics. The chi-square test with Yate's correction for continuity was applied to small samples or when at least one expected value fell below 10 (after Blalock, 1979; Thomas, 1986). The Fisher's exact probability test, on the other hand, was used in the analysis of very small samples or when at least one expected value fell below 5 (after Blalock, 1979; Thomas, 1986).

Because Fisher's exact test may only be applied to 2x2 contingency tables (Blalock, 1979), the Cemetery B and Great Cemetery frequencies of porotic hyperostosis were pooled for comparisons with Cemetery T. This was possible because it was previously reported that Cemetery B and the Great Cemetery are similar archaeologically (Baumgartel, 1970) and genetically (Johnson and Lovell, 1994). The pooled frequencies were used for all comparisons in order to maintain consistency.

The effects of sex and age at death on the frequencies of porotic hyperostosis of the vault and orbits were analyzed. It was necessary to control sex while examining the differences due to age, and alternatively to control age while examining the differences due to sex, because the demographic profiles differed within and between the Naqada cemeteries.

Following the assessment of the demographic variables, the relationship of health and social status was evaluated by comparing disease frequencies between the cemeteries. It was important to avoid Simpson's Paradox, which refers to the possibility of obtaining inaccurate results when the effects of variables extraneous to the primary comparison are disregarded (Fingleton, 1984; O'Brien, 1989; Simpson, 1951; Upton, 1986). Although multivariate statistical techniques minimize Simpson's Paradox (Freeman, 1987; O'Brien, 1989; Upton, 1986), the Naqada samples sizes were too small for such analyses. Instead, the accessory variables (e.g. age and sex) were simultaneously controlled (after Blalock, 1979) by holding each at a constant value while testing for relationships among the primary variables (e.g. status). This procedure was repeated for every possible expression of the extraneous variables. The frequencies of porotic hyperostosis were compared between the cemeteries for each sex and age combination, such as young adult females, young adult males, middle adult females, and so on.

RESULTS AND DISCUSSION

OVERALL FREQUENCIES

The overall frequency of cribra orbitalia observed in the Naqada skulls is 40.4%, while the prevalence of porotic hyperostosis of the vault is 62.7%. In general, it is thought that porotic hyperostosis of the vault and orbits are related and share a common etiology. The exact relationship between the lesions is controversial, however, because the two types of lesions are not always observed together in a single skull (Stuart-Macadam, 1989b). At Naqada, for example, the frequencies of porotic hyperostosis of the vault were not statistically associated with those of the crania. Differences between the vault and orbital lesions may be explained by variable thicknesses of the external tables. The surface of the orbital roof is much thinner than that of the vault, and, as a result, lesions may develop earlier in the orbits (Steinbock, 1976). Despite the lack of statistical association, the frequencies of porotic hyperostosis at Naqada of both the vault and orbits revealed similar patterns with respect to age, sex, and social status.

AGE

A formal statistical evaluation of the effects that age has upon the prevalence of porotic hyperostosis was not possible because of very small subsample sizes. In general, no distinct trends, such as an increase or decrease of the lesions with age, were apparent. The frequencies of cribra orbitalia and porotic hyperostosis in the vaults varied among the age groups, but did not appear to be associated with age in any way (Table 6-1). If the condition was obtainable throughout life, an increase with age might be expected, but this is not reflected in the frequencies of porotic hyperostosis at Naqada.

The lack of age differences is consistent with the suggestion that porotic hyperostosis represents a childhood condition (Stuart-Macadam, 1985). The frequencies do not increase with age, because they were acquired early on, evidence of which is retained in the adult skulls. This is not to suggest that individuals cannot acquire anemia in adulthood, but rather, that skeletal changes are limited to children affected by the condition (Stuart-Macadam, 1985).

Two important distinctions between subadult and adult bone may help to explain this differential lesion susceptibility with respect to age. First, subadult bone, which is continually growing, has a greater plasticity than adult bone. The bones of anemic children are therefore more vulnerable to expanding marrow pressures. Second, the distribution of red hematopoietic bone marrow differs between subadults and adults. In children, red bone marrow is found throughout the body, whereas in adults, it is generally limited to the sternum, vertebrae, ribs, coxae, and cranium (Lewis, 1989). In adults, therefore, the increased production of red blood cells can cause the marrow to expand into areas normally occupied by yellow fatty marrow. Conversely, in children, expansion is limited because all available marrow space contains red marrow.

In addition to bone plasticity and marrow distribution differences, subadults are especially susceptible to developing anemia, because of the increased demand for iron during growth (Dallman, 1989; Pippard and Hoffbrand, 1989). Iron is also needed for brain neurotransmissions, physical and cognitive activities, and especially for oxygen transport from the lungs to the tissues (Lewis, 1989; Pippard and Hoffbrand, 1989). The symptoms of anemia observed in infants and children reflect the importance of iron. Anemia can negatively influence mental and physical development in subadults, resulting in learning disabilities, shortened attention spans, decreased growth, delayed sexual maturation, and impaired motor development (Pippard and Hoffbrand, 1989). However, severe examples of clinical anemia are usually limited to subadults over six months of age, because during the first six months of life infants are protected from infections and iron deficiency by passive immunity and iron stores acquired from the mother (Pippard and Hoffbrand, 1989).

The results presented here are consistent with those of other Egyptian and Nubian palaeopathological studies which have also failed to find differences attributable to age (Carlson et al., 1974; Hillson, 1980; Stuart-Macadam, 1985). For example, similarities in porotic hyperostosis frequencies among different age groups have been reported among Egyptians from Predynastic through Christian times (Hillson, 1980).

SEX

Although the frequencies of porotic hyperostosis of the vault revealed no statistically significant differences between females and males when age and cemetery variables were controlled, significant sex differences were apparent with respect to orbital lesions (Table 6-2). Significantly more middle adult females from the combined B and Great Cemeteries (60.0%) were affected by cribra orbitalia than were middle adult males (19.1%). Similarly, middle adult females from the combined B and Great Cemeteries revealed higher frequencies of porotic hyperostosis of the vault (80.0%) compared with middle adult males (47.6%), although the difference was not statistically significant.

These variations due to sex are consistent with the results reported by clinical studies in which females have higher frequencies of anemia than do males. Although the percentage of anemia is similar between the sexes during infancy and childhood (Garn, 1992), the prevalence is higher in females from adolescence onward (Pippard and Hoffbrand, 1989). The difference may be associated with menarche in females (Pippard and Hoffbrand, 1989), but it may also be due to variable levels of iron. Beginning in their adolescent years, males have more iron than females. Not only do males ingest more iron through the consumption of greater quantities of food, male hormones also facilitate higher iron levels. Testosterone, for example, is known to increase hemoglobin concentrations (Lewis, 1989). Males, throughout most of their adult lives, not only have higher hemoglobin concentrations but also higher hematocrit levels (Garn, 1992). Although females are better able to absorb iron from the diet, they lose iron to menstruation and to the added demands of pregnancy (Wadsworth, 1992). Premenopausal women with menorrhagia, or excessive menstrual flows, are especially vulnerable to iron deficiency anemia (Arthur and Isbister, 1987; Garn, 1992; Pippard and Hoffbrand, 1989).

Differences in the frequencies of porotic hyperostosis between the sexes at Naqada are limited to middle adults or the latter stages of the reproductive years. This may reflect the added demands for iron required by pregnancy and especially multiparity. Pregnant women have the greatest demands for iron, and are therefore very susceptible to iron deficiency anemia (Arthur and Isbister, 1987; Carlson et al., 1974; Pippard and Hoffbrand, 1989). Iron is required for the placenta and the growing fetus, and for an increased maternal red blood cell mass (Arthur and Isbister, 1987; Cook, 1990). Women in their second or third trimesters of pregnancy are particularly at risk because their iron stores become depleted (Dallman, 1992; Pippard and Hoffbrand, 1989). Although the body attempts to adapt to the added demands of pregnancy by increasing the synthesis and iron-binding capacity of transferrin (Arthur and Isbister, 1987), iron deficiency is common nonetheless. The implications of anemia during pregnancy may include increased infant prematurity and neonatal death, and decreased gestation and birth weights (Cook, 1990; Dallman, 1989; Garn, 1992). The possibility of developing anemia increases further with multiparity (Arthur and Isbister, 1987). In Egypt, since ancient times, it is common to have several offspring. Multiparity has been associated with high female mortality in child-bearing years, which suggests that successive pregnancies are particularly stressful (Carlson et al., 1974; Hillson, 1980).

Although porotic hyperostosis is thought to represent a childhood condition, adult anemia possibly influences lesion remodelling in affected vaults and orbits. Marrow pressure caused by an increased production of red blood cells continues to affect adults, because red bone marrow is retained in the adult skull. Although adult bone may be resistant to developing new porotic lesions, marrow pressure may affect lesion healing. Middle adult females at Naqada may have revealed high frequencies of porotic hyperostosis because of a continuation or a recurrence of anemia. The skeletal lesions likely developed during infancy or childhood, but anemia in later years would have prevented complete healing. Middle adult males, in comparison, may have had a better chance of recovering from childhood episodes of anemia and hence revealed lower frequencies of porotic hyperostosis.

SOCIAL STATUS

No statistically significant differences in the frequencies of cribra orbitalia were found when the status groups were compared. However, low status middle adult females revealed significantly higher frequencies of porotic hyperostosis of the vault when compared to high status middle adult females (Table 6-3).

Social stratification may have an effect upon the frequencies of porotic hyperostosis, because social status influences lifestyle. Socioeconomic status affects factors related to the etiology of anemia, including subsistence, diet, living conditions, and sanitation and hygiene.

Chronic blood loss is the most common cause of iron deficiency in humans (Arthur and Isbister, 1987; Pippard and Hoffbrand, 1989; Stuart-Macadam, 1992b). Unusual bleeding may be caused by intolerance to cow's milk (Pippard and Hoffbrand, 1989), bladder polyps (Arthur and Isbister, 1987; Pippard and Hoffbrand, 1989), peptic ulcers (Arthur and Isbister, 1987; Garn, 1992; Pippard and Hoffbrand, 1989), colitis (Arthur and Isbister, 1987), menorrhagia (Arthur and Isbister, 1987; Garn, 1992; Pippard and Hoffbrand, 1989), and especially gastrointestinal parasitic diseases (Garn, 1992). Hookworms and malaria parasites, for example, commonly cause iron deficiency in their human hosts (Carlson et al., 1974; Pippard and Hoffbrand, 1989). In addition, red blood cells may actually be destroyed by the malaria parasite. Past populations were often heavily affected by such parasites (Garn, 1992). In ancient Egypt, hookworms and schistosomes (Carlson et al., 1974), which are still common today, likely had a large influence on the prevalence of iron deficiency anemia. Parasites in ancient Egypt were influenced by the climate and geography of the Nile Valley. The annual Nile floods, for example, produced an environment favorable to such parasites. The ancient Egyptians settled along this floodplain, because of their increased reliance on plant cultivation, and, subsequently were exposed to these parasites.

Iron deficiency anemia has often been attributed to dietary insufficiencies, in addition to chronic blood loss. Iron is an insoluable metal that must be obtained from the diet (Pippard and Hoffbrand, 1989). Diets lacking in zinc, vitamin B12, protein, calories, and especially iron are thought to contribute to the development of anemia (El-Najjar, 1976; Garn, 1992). Porotic hyperostosis, as a result, is sometimes classified as a nutritional stress indicator (Hummert and Van Gerven, 1983; Huss-Ashmore et al., 1982; Stuart-Macadam, 1992b). Sharp increases in porotic hyperostosis have been associated with the development of agriculture during Neolithic times (Cohen and Armelagos, 1984). Cereal grains do not contain much iron and cereal grain phytates inhibit the absorption of the limited amounts of iron that are present (Garn, 1992; Stuart-Macadam, 1992b). Because the Predynastic era is associated with the latter stages of the Neolithic in ancient Egypt, the relatively high prevalence of porotic hyperostosis at Naqada was not unusual.

The presence of social stratification in Predynastic Egypt may have affected dietary insufficiencies and, ultimately, porotic hyperostosis frequencies at Naqada. Although the basic diet of bread, vegetables, and fruit was similar between the lower and higher status groups in ancient Egypt (Hillson, 1979; Saffirio, 1972; Wilson, 1988), the higher status individuals apparently had better access to iron-rich meat, which contains heme iron that is more easily absorbed than the more plentiful non-heme food (Cook, 1990). The problems of keeping meat fresh in such a hot climate "led to an apparent class distinction in the eating of meat" (Wilson, 1988: 35), at least during Dynastic times. Texts and temple reliefs indicate that beef, for example, was a particularly prestigious offering (Wilson, 1988).

Although diet is related to the prevalence of anemia, it is rarely the only factor (Arthur and Isbister, 1987; Kent, 1992). The body is well adapted to maintaining iron levels since iron is recycled. Iron that is needed for the production of new red blood cells, for example, is obtained from destroyed old red blood cells. It has been estimated that an iron-free diet would only result in anemia after many years (Arthur and Isbister, 1987; Pippard and Hoffbrand, 1989). Because the intestine is fairly adaptable to lowered iron levels, dietary iron intake as a causative factor of anemia is not as crucial as was once thought (Kent, 1992). On the other hand, although dietary intake may be sufficient, the gastrointestinal absorption of iron may be inhibited. While some factors, such as ascorbic acid, enhance iron absorption (Cook, 1990; Pippard and Hoffbrand, 1989), other dietary factors, such as excess fibre and cereal grain phytates, limit the bioavailability of iron.

In addition to inhibited iron absorption, pathogen loads may help to explain the prevalence of anemia and porotic hyperostosis in populations with adequate diets (Stuart-Macadam, 1992a). Mild iron deficiency may actually be adaptive since the body appears to withhold iron when affected by bacteria, viruses, parasites, and neoplasms (Arthur and Isbister, 1987; Kent, 1992; Pippard and Hoffbrand, 1989). The body defends itself against such pathogens by increasing the iron-binding capacity or saturation level of transferrin so that iron can be more easily removed from circulation (Arthur and Isbister, 1987; Kent and Weinberg, 1989; Weinberg, 1984, 1992). Pathogens require iron for replication and growth, but are unable to store the metal in non-toxic forms (Kent, 1992; Kent and Weinberg, 1989). As a result, they must rely on the host for necessary iron levels. Decreased circulating iron levels have been associated with decreased frequencies of infections, whereas excess iron levels have been related to increases in pathogen loads (Weinberg, 1984, 1992). Hypoferremia may therefore be a normal physiological response rather than a pathological condition (Weinberg, 1992). Although anemia may eventually result if the hypoferremic condition is severe or prolonged, the symptoms are often less devastating than the diseases that would have otherwise occurred.

Pathogen loads are largely a function of sanitation, hygiene, and crowding. Although the Predynastic Egyptians were not subjected to crowding, due to the lack of large urban settlements at that time (Hassan, 1988), they likely encountered sanitation problems. The small Predynastic communities may have provided a suitable environment for disease organisms, because the dwellings were located in close proximity to animal enclosures and trash heaps (Hassan, 1988; Kemp, 1991). It is difficult to interpret the effects that social stratification had upon the living conditions of higher and lower status individuals, however, because Predynastic settlement evidence is limited. Cemetery evidence suggests that the higher status individuals were buried in exclusive locations, such as in Cemetery T at Naqada. The Predynastic Egyptians, by analogy, may also have resided in areas segregated from the rest of the populace, and, as a result, were at a lower risk of infection. Modern analogies suggest that individuals of high status have better hygiene and living conditions than do individuals of low status.

Thus, higher status females were better adapted to the additional stresses of pregnancy than were the lower status females, because of their more nutritious diets, superior hygiene, and lower risk of infections.

CONCLUSIONS

The results of this study reveal several important patterns in the prevalence of porotic hyperostosis in the Predynastic site of Naqada. First, there is a high overall frequency of anemia represented by cribra orbitalia and porotic hyperostosis of the vault. The prevalence of anemia is likely related to ancient Egyptian environmental factors. The Nile-dominated geography of Egypt allowed for the cultivation of cereal grains which formed the basis of the diet. Cereal grain phytates, however, inhibit the absorption of iron which may have contributed to the rates of anemia observed at Naqada, although the role of diet as a cause of iron deficiency anemia has recently been downplayed (Stuart-Macadam, 1992a, 1992b). The Nile River habitat is also responsible for high rates of parasitic and bacterial infections among Egyptians. Schistosomiasis, for example, is a common infection of modern Egyptians and may have affected ancient Egyptians as well (Millet et al., 1980; Mobarek, 1982). Second, there are no apparent differences in the frequencies of porotic hyperostosis between the age groups when sex and cemetery are controlled. This is consistent with the theory suggested by Stuart-Macadam (1985) that skeletal lesions are indicative of a childhood condition. Third, the patterns of porotic hyperostosis specific to middle adult females from Naqada may be explained by the added demands for iron required by pregnancy. The need for additional iron would have placed an extra strain on pregnant females who may have already been iron deficient due to diet or infection. As a result, they may have been especially prone to developing anemia. Finally, social status likely had an indirect effect on the frequencies of anemia among middle adult females. Higher status females were apparently better adapted to the added stresses of multiparity.

Table 6-1. Comparisons of porotic hyperostosis frequencies among the age groups at Naqada.

Cemetery and Sex	Young Adult		Middle Adult		Old Adult		Test & P-Value
	#/n	%	#/n	%	#/n	%	
VAULT LESIONS							
B and Great Cemeteries							
Female	2/6	33.3	4/5	80.0	5/11	45.5	-
Male	4/7	57.1	10/21	47.6	11/24	45.8	-
Cemetery T							
Female	-	-	1/7	14.3	2/5	40.0	-
Male	-	-	2/5	40.0	2/11	18.2	-
ORBITAL LESIONS							
B and Great Cemeteries							
Female	3/6	50.0	3/5	60.0	5/11	45.5	-
Male	2/6	33.3	4/21	19.1	11/21	52.4	-
Cemetery T							
Female	-	-	3/6	50.0	2/5	40.0	-
Male	-	-	1/5	20.0	5/11	45.5	-

Note: '#' = number of affected individuals; 'n' = total number of individuals in the subsample; '%' = percentage of the subsample affected with skeletal lesions; '-' = unobservable values or statistical test not possible; '*' = statistically significant.

Table 6-2. Comparisons of porotic hyperostosis frequencies between the sexes at Naqada.

Cemetery and Age	Female		Male			
	#/n	%	#/n	%	Test	P-value
VAULT LESIONS						
B and Great Cemeteries						
Young Adult	2/6	33.3	4/7	57.1	Fisher's	0.59
Middle Adult	4/5	80.0	10/21	47.6	Fisher's	0.33
Old Adult	5/11	45.5	11/21	45.8	Yate's	1.00
Cemetery T						
Young Adult	-	-	-	-	-	
Middle Adult	1/7	14.3	2/5	40.0	Fisher's	0.52
Old Adult	2/5	40.0	2/11	18.2	Fisher's	0.55
ORBITAL LESIONS						
B and Great Cemeteries						
Young Adult	3/6	50.0	2/6	33.3	Fisher's	1.00
Middle Adult	3/5	60.0	4/21	19.1	Fisher's	0.10*
Old Adult	5/11	45.5	11/21	52.4	Fisher's	1.00
Cemetery T						
Young Adult	-	-	-	-	-	
Middle Adult	3/6	50.0	1/5	20.0	Fisher's	0.55
Old Adult	2/5	40.0	5/11	45.5	Fisher's	1.00

Note: '#' = number of affected individuals; 'n' = total number of individuals in the subsample; '%' = percentage of the subsample affected with skeletal lesions; '-' = unobservable values or statistical test not possible; '*' = statistically significant.

Table 6-3. Comparisons of porotic hyperostosis frequencies between the cemeteries at Naqada.

Sex and Age	BG		T			
	#/n	%	#/n	%	Test	P-value
VAULT LESIONS						
Female						
Young Adult	2/6	33.3	-	-	-	
Middle Adult	4/5	80.0	1/7	14.3	Fisher’s	0.07*
Old Adult	5/11	45.5	2/5	40.0	Fisher’s	1.00
Male						
Young Adult	4/7	57.1	-	-	-	
Middle Adult	10/21	47.6	2/5	40.0	Fisher’s	1.00
Old Adult	11/24	45.8	2/11	18.2	Fisher’s	0.15
ORBITAL LESIONS						
Female						
Young Adult	3/6	50.0	-	-	-	
Middle Adult	3/5	60.0	3/6	50.0	Fisher’s	1.00
Old Adult	5/11	45.5	2/5	40.0	Fisher’s	1.00
Male						
Young Adult	2/6	33.3	-	-	-	
Middle Adult	4/21	19.1	1/5	20.0	Fisher’s	1.00
Old Adult	11/21	52.4	5/11	45.5	Yate’s	1.00

Note: ’BG’ = combined B and Great Cemeteries; ’T’ = Cemetery T; ’#’ = number of affected individuals; ’n’ = total number of individuals in the subsample; ’%’ = percentage of the subsample affected with skeletal lesions; ’-’ = unobservable values or statistical test not possible; ’*’ = statistically significant.

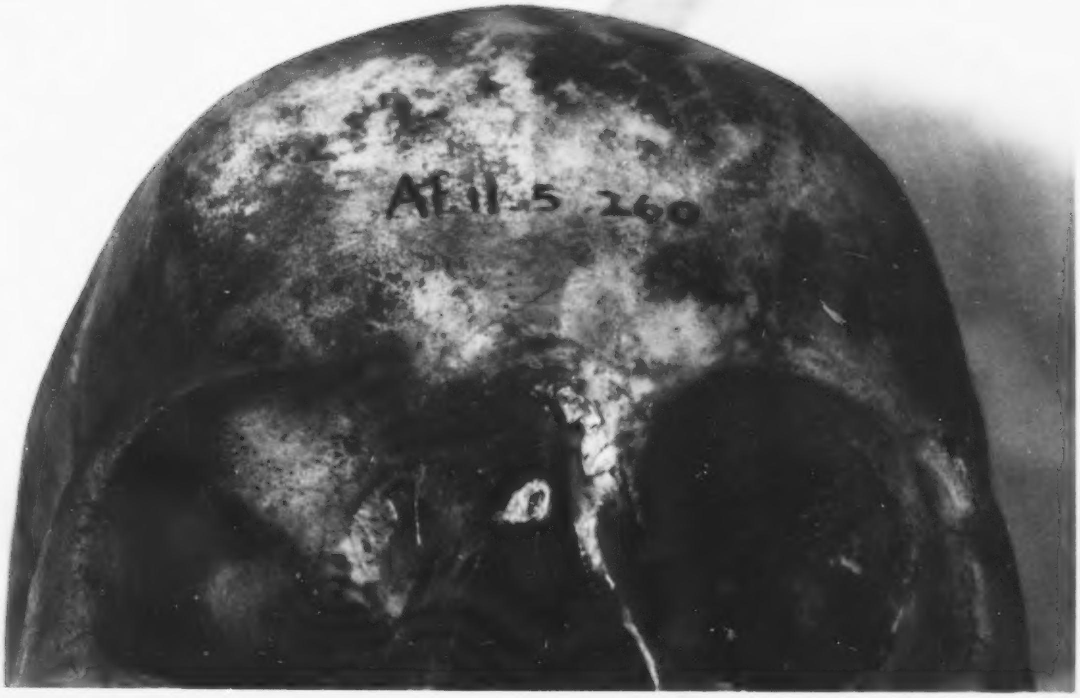

Plate 6-1. An example of cribra orbitalia (Female, 24-30 years, Great Cemetery, Grave #1832, Duckworth #Af.11.5.260).

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Chapter 7:
CONCLUSIONS

The impact that social status had upon the lifestyles and health of the Predynastic Upper Egyptians from Naqada appears to have been limited to middle adult females, despite the fact that social stratification was clearly represented in the Naqada cemeteries by differences in the quality and quantity of grave goods and the sizes of the graves. Lower status middle adult females revealed significantly higher frequencies of porotic hyperostosis of the vault than did higher status middle adult females. The conditions encountered by the Naqada inhabitants were especially stressful for middle adult females because, in addition to gastrointestinal parasites, iron-deficient diets, and infections, they experienced extra strains caused by multiparity and lactation. Therefore, the ability to adapt to these added stresses was likely influenced by social status.

The results of this analysis also reveal that the ancient inhabitants of Naqada were affected by biparietal thinning, localized infection, atlanto-occipital arthritis, and, especially, temporomandibular joint arthritis. The biocultural context of ancient Egypt may explain why its early inhabitants suffered from such conditions. The unique Nile-dominated geography of Egypt created a homogenous and restricted environment that allowed for the development of one of the earliest and most spectacular ancient civilizations under otherwise harsh and sterile conditions. The subsequent development of agriculture produced conditions conducive to parasitic infection and the consumption of gritty, iron-deficient diets. These factors were likely responsible for causing the observed high frequencies of temporomandibular joint arthritis and porotic hyperostosis in the Naqada skulls.

This skeletal analysis has provided a unique opportunity in which to comprehend better the Egyptian Predynastic period in general. Although Predynastic remains are often overlooked in favor of the more accessible and spectacular Dynastic materials, study of the earlier formative period provides valuable information pertaining to the roots of the ancient Egyptian civilization. The analysis of the Naqada skeletal remains indicates that the lifestyles of the ancient Predynastic inhabitants did not yet differ greatly between the emerging social classes. The frequencies of temporomandibular joint arthritis, for example, were virtually identical between the cemeteries despite status differences.

Analyses of the Naqada disease frequencies were sometimes restricted by small subsample sizes. Limited samples were unavoidable because Cemetery B and Cemetery T are represented by a small number of graves. This problem may be alleviated in future analyses by augmenting the Naqada material with similar Predynastic skeletal samples.

Appendix:
STATISTICAL FORMULAE[1]

CHI-SQUARE TEST:

$$X^2 = \Sigma \frac{(O_{ij} - E_{ij})^2}{E_{ij}} \quad \text{on degrees of freedom } (r-1)(c-1)$$

where O= observed number of cases
E= expected number of cases, = $\frac{r_i c_j}{n}$
n= total number of observations
i= each row
j= each column
r= total number of rows
c= total number of columns

YATE'S CORRECTED CHI-SQUARE TEST:

$$X^2 = \Sigma \frac{(|O_{ij} - E_{ij}|-0.5)^2}{E_{ij}} \quad \text{on degrees of freedom } (r-1)(c-1)$$

where O= observed number of cases
E= expected number of cases, = $\frac{r_i c_j}{n}$
n= total number of cases
i= each row
j= each column
r= total number of rows
c= total number of columns

FISHER'S EXACT PROBABILITY TEST:

$$Pr = \frac{(A+B)!(C+D)!(A+C)!(B+D)!}{N!A!B!C!D!} \quad \text{for each possible table with fixed margins}$$

p = 2 x min [probability of obtaining a table as extreme as or more extreme than the observed table]

where Pr= each exact probability value
A, B, C, D= represent the cells in a 2x2 contingency table
N= total number of cases
p= final exact probability value

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[1] Formulae derived from Rosner, 1990 and Siegal and Castellan, 1988 (cited in Chapter 3).